The

ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XX No. 4 APRIL, 1959

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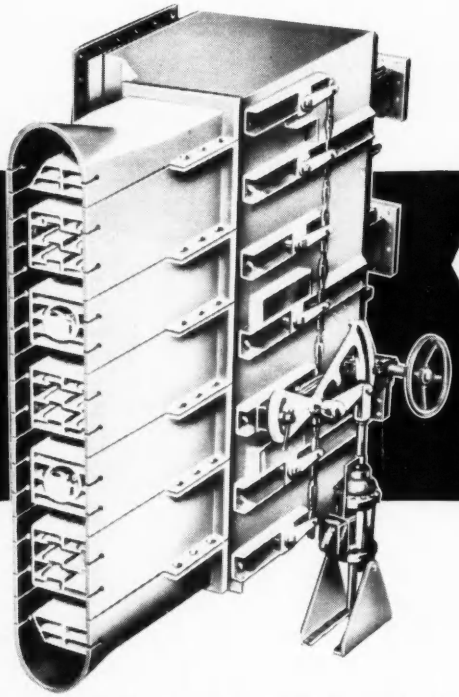

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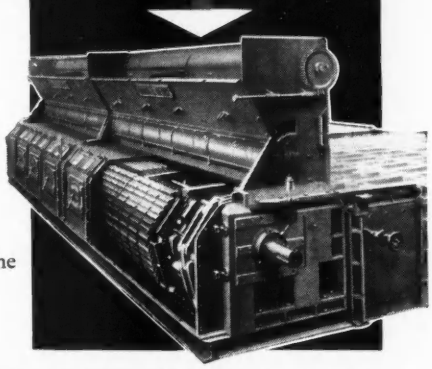

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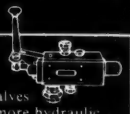

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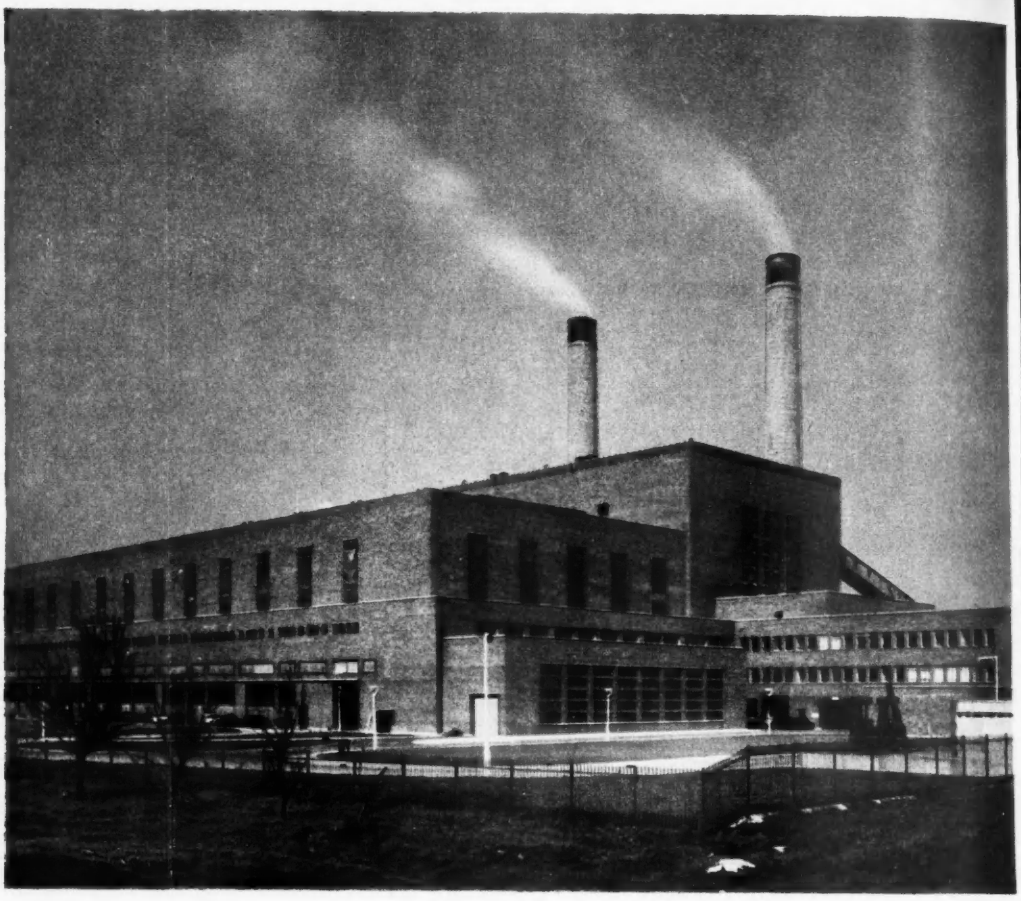

"Etaflo" Water Tube Boilers at Tilbury

For the Central Electricity Generating Board's power station at Tilbury John Thompson have supplied 6 pulverised fuel "Etaflo" boilers of 60 m.w. These boilers are arranged for alternative oil firing.

Boilers of the same type are in operation at Brimsdown, Marchwood and Bold power stations. Work is now in progress on the Central Electricity Generating Board's contract for Richborough incorporating two "Etaflo" boilers of 120 m.w.

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

• *DYNAMIC LOADING OF SPUR-GEAR TEETH*

The dynamic loading of spur-gear teeth is the maximum momentary load imposed on the gear teeth by the conditions of service, including the influence of errors in the teeth. The extent and nature of dynamic loading have long been open questions, and assessment of its magnitude has always entailed a considerable amount of guesswork, coupled with the use of various empirical and theoretical formulae. In a recent investigation, however, electrical strain gauges have been used to record the actual deflections of the teeth and to measure the maximum instantaneous load on each tooth as it traverses the contact zone at different speeds and under different loads. The recorded traces represent the deflections of the strain-gauge point under the applied load at different points on the tooth profile and provide a clear picture of tooth behaviour as the result of load conditions and the elastic properties of the material. They also show the effect of speed, of irregularity of motion, and of the applied load on the maximum momentary load on the tooth. The dynamic effect of pitch errors on tooth loading has been studied by comparing the traces recorded at different speeds. These tests confirm that it is possible to study in this way the deflections of the gear tooth under load and accordingly to investigate the static and dynamic loading on the tooth. It is shown that the strain in the body of the gear causes the tooth to deform before it comes into mesh, this deformation, together with the existing base pitch errors between the teeth, causing impacts, sudden rises, and drops in the load curves of the tooth and resulting in the occurrence of dynamic increments of load when the gears run at speed.

• *MAGNESIUM-LITHIUM ALLOYS*

According to a recent report, magnesium alloys containing up to 10 or 15% lithium are being investigated for possible use in aircraft, missiles, and other applications. The use of lithium as an alloying constituent is based on the fact that it is the only element capable of converting the hexagonal lattice structure of magnesium to the more ductile body-centred cubic structure. Furthermore, the alloy has a markedly lower density than magnesium. Investigations have also been carried out to develop fluxes and procedures for melting these alloys. Experiments have shown that the hexagonal-phase magnesium-lithium alloys are more readily cold-worked than unalloyed magnesium, but are not as ductile as the apha-beta alloys, the most ductile being the all-beta alloys, which contain 10·3% or more lithium. These binary alloys, although ductile, are weak, but can be strengthened by the addition of aluminium, zinc, cadmium, silver, mercury, thallium, indium, or gold, which are the most soluble elements. Alloys containing at least 8% lithium and a sufficient addition of certain of the above elements can be solution-heat-treated, quenched, and aged to produce exceptionally high strength, up to 60,000 psi, though they tend to lose strength at temperatures only slightly above room temperature—a characteristic which has prevented their commercial use. Although the reason for this instability of these high-strength alloys is understood, no way of overcoming this drawback has so far been found. The corrosion resistance of the 11% lithium binary alloy, however, compares favourably with that of a commercial magnesium-manganese alloy.

• *ANALOGUE COMPUTER FOR ESTIMATING THE RESISTANCE OF STRUCTURAL MATERIALS TO FIRE*

A special analogue computer has been developed which analyses and make it possible to estimate rapidly transient heat flow in building materials and structures. Although its use is not likely to eliminate the need for full-scale fire tests, it is expected to be useful in reducing their number. Fire-resistance tests are often performed on portions of buildings to determine how well the construction can withstand the effects of fire. However, the expense of building the test specimen and the considerable time required to perform the test make desirable some high-speed method of estimating the fire resistance of structures. The new method provides a solution by using a direct analogy between thermal and electrical circuits. This type of analogy permits considerable flexibility in solving heat-flow problems and also simplifies the coding of problems and eliminates the large assembly of electronic mathematical-operator units which conventional computers require to solve the problem of heat transfer by conduction. The computer is of the " fast-time " type, in which a problem can be solved repetitively at a speed much higher than can be obtained with an actual test specimen. Essentially, it applies vol-

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tage signals corresponding to the prescribed temperature/time conditions of a standard fire test to an electrical model representing the material under study, and then displays on a cathode-ray tube the resulting temperature/time curve at any of several points within the material. The equipment basically consists of a signal-generating unit, means for applying the signal to an electrical network, and circuitry to measure the transient voltages within the model.

● *MACHINABLE AND HARDENABLE CEMENTED CARBIDES*

The recent development of cemented carbide materials which can be machined to shape in the annealed condition and then hardened for use may be said to represent an important advance in tool engineering. These materials are steel-bonded carbides, such as tungsten and titanium carbide, which can be machined by conventional means in the annealed state, their hardness varying from 38 to 42 Rockwell *C*. After machining, heat treatment is carried out by oil-quenching from 1750°F in a medium oil, imparting a Rockwell *C* hardness of 69 to 71. It is reported that this material has been used in a variety of metal-working operations, including blanking, cold heading, slitting, forming, drawing, curling, and deep-drawing, and has proved itself on many metals, including nickel alloys, stainless steel, mild and alloy steels, brasses, and phosphor-bronze. The use of these carbide materials should enable tool inventories to be cut considerably, as special shapes can be fabricated quickly from a stock of annealed blanks. Since it is possible to re-anneal and re-process these carbides, it is possible to correct errors in die design or to modify tools so as to make minor changes in part design.

● *INTERNAL RESISTANCE MEASUREMENT OF DRY CELLS*

A new non-destructive technique for measuring the true internal resistance of dry cells, based on the employment of a repetitive pulse, is reported to have proved useful in determining how internal resistance changes as the cell is discharged under various test conditions on continuous or momentary current drain. The results of these tests show that an increase in internal resistance depends on the type of discharge, cell size, and variations in manufacture. In this new technique, the circuit consists of a pulse generator, a resistor of known value, and the test cell, all connected in series, a cathode-ray oscilloscope being the only additional piece of equipment required. The oscilloscope leads are first connected to the cell terminals and, with the pulse generator applying a train of pulses to the cell, the instantaneous internal-resistance drop is recorded at the trailing edge of the pulse displayed on the oscilloscope screen, this "instantaneous" drop of the oscilloscope pattern occurring in about 10^{-7} sec. The oscilloscope is then connected across the known resistor, the instantaneous internal-resistance drop is noted, and the current through the resistor is calculated from Ohm's law. Knowing the current in the pulse, the resistance of the dry cell can thus be calculated by applying Ohm's law to the resistance drop in the cell in the first measurement.

● *CONTROL OF ACCIDENTAL ELECTRICAL CURRENTS IN BEARINGS*

A recent article discusses the various cases in which the accidental presence of electrical currents in bearings can arise in electrical machines and how these currents can be controlled in order to avoid damage to bearings by pitting. Even though a potential is not directly applied to a shaft, bearing currents may arise through induced effects in various types of machines. If an alternator could be so perfectly constructed that the reluctance of the magnetic circuit is uniform around the periphery of the stator, no bearing currents would be generated. However, various sources of dissymmetry may be present, such as differences in the spaces between the ends of laminations and asymmetrical distribution of slots, and in such cases it is recommended that one bearing be insulated. If one bearing is insulated and if the shaft on that end of the machine is metallically connected to the shafts of other machines, all bearings of the other machines should also be insulated; alternatively, both ends of the shaft should be earthed. The passage of a lubricant through certain types of filters results in the molecules of the lubricant becoming electrically charged. Since the lubricant is essentially a non-conducting medium, some of the molecules may remain charged, even after passing a considerable length of earthed pipe, and charges transported in this manner may be deposited on the journal. In order to prevent build-up of dangerous potentials, all bearings, as well as the shaft, should be earthed, so as to prevent the discharge of an electrostatic potential through the oil film.

● *OCEAN-BOTTOM PHOTOGRAPHIC RECORDER*

An ocean-bottom photographic recorder has been developed in which a camera takes electronic flash-light colour pictures at great depths. The device signals the operator on the surface when the exposure is made, and the camera is then ready to proceed to the next location. The recorder has been designed to operate at depths as great as 1200 ft, i.e., to withstand a pressure of more than 500 psi. Another component involved in working at such depths is the hauling cable, since the combined weight of the camera

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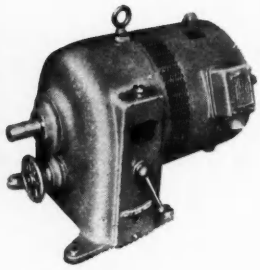
and the extended length of cable must be borne by any given cross-section of the cable. Pressure requirements are met by using a stainless-steel pipe, $\frac{1}{4}$ in. in thickness and $4\frac{1}{2}$-in. o.d., for the construction of the camera case. The main section of the camera is some 3 ft in length and houses a central battery pack for supplying power for the electronic flash unit and for the motor operating the camera. The camera section is about 15 in. in length, and the flash unit about 7 in. Both the power unit and the camera unit are of the integral plug-in type, so that they can be readily replaced if repairs are necessary. A completely self-contained and self-powered transducer is incorporated and informs the surface vessel that the camera has reached the ocean floor and that a picture has been taken. The shutter movement simultaneously sets off the electronic flash, and the transducer then emits a 9-kcs underwater signal which can be heard by means of a hydrophone mounted on the hull of the surface vessel. The camera has two lenses and takes two pictures of the same subject simultaneously, but at slightly different angles, so that a three-dimensional effect of depth is obtained when the pictures are examined in a stereoscope. It is claimed that this stereoscopic effect is eminently suitable for obtaining an accurate analysis of the ocean bottom.

• *IMPROVED HOT-WORKING PROPERTIES OF TITANIUM ALLOYS*

The forging, rolling, and extrusion of titanium alloys require relatively high forces which increase as the working temperature decreases. Moreover, with increasing quantities of aluminium in these alloys, the resistance to deformation increases to such an extent that very high working temperatures are required, as, with lower temperatures, they cannot be worked with the power available or tend to crack. For this reason, titanium alloys containing over 6% aluminium cannot normally be used on a commercial scale. Pure titanium is strongly embrittled at room temperature by the presence of hydrogen in the material, while many titanium alloys are embrittled at room temperatures by the presence of only very small quantites of hydrogen, this embrittlement causing a lowered impact resistance. However, while it was previously believed that hydrogen has only deleterious effects on titanium alloys, it is now claimed in a recently patented process that the hot-workability of titanium can actually be improved by a content of hydrogen. For example, when a titanium alloy is melted in the presence of hydrogen so that it takes up hydrogen, the resulting hydrogen-containing alloy is much more easily hot-worked than the hydrogen-free alloy. In order to obtain good mechanical properties in the hot-worked product, it is generally necessary to remove the hydrogen after hot-working has been completed. It is stated that the quantity of hydrogen required to improve the hot workability of titanium alloys depends upon the composition of the individual alloy, but should generally be between 0·05 and 1·0% by weight. The hydrogen can be incorporated in various ways, the simplest method being to melt down the titanium alloy in a hydrogen atmosphere. It is stated that the addition of hydrogen stabilizes the beta-phase of the titanium alloy at the hot-working temperature, with a marked improvement in its hot-working properties, and is particularly advantageous with titanium alloys containing more than 6% of aluminium.

• *NEW GASEOUS MEDIUM FOR ARC INTERRUPTION IN CIRCUIT-BREAKERS*

A recent report points out that sulphur-hexafluoride gas may be expected to become an important interrupting medium for high-power arcs in circuit-breakers. Sulphur hexafluoride, which was first developed and applied as an insulating medium, has a dielectric strength at atmospheric pressure of from two to three times that of air, and this strength increases with increasing pressure. At 3 atm its dielectric strength is approximately that of transformer oil, but its real value lies in its unique arc-quenching property, which, under certain conditions, may be one-hundred times greater than that of air. Sulphur hexafluoride is one of the halogen-compound gases, is extremely stable and inert, remains a gas down to —62°C at atmospheric pressure, is non-toxic and non-inflammable, odourless and colourless, and has a density approximately five times that of air. The phenomenon apparently responsible for the superior arc-quenching abilities of sulphur hexafluoride is the effect of negative ion formation by electron capture on electric discharges. Certain molecules offer an attraction for free electrons and combine with the electrons to become negatively charged ions. Gases made up of molecules with this electron-attracting characteristic are termed electro-negative, and sulphur hexafluoride is one of the best electro-negative gases. When the electrons are captured, sulphur hexafluoride and pentafluoride ions are formed, both being massive and therefore relatively ineffective as current carriers. The insulating and arc-quenching abilities of sulphur hexafluoride are strongly affected by this electron-capturing action, but the mechanisms of electrical breakdown and arc-quenching are so dissimilar in detail that the quantitive effects observed are quite different. The extremely rapid capture of free electrons in the path of the arc through the electro-negative process is believed to be the explanation why the time-constant of sulphur hexafluoride is only a fraction that of air.



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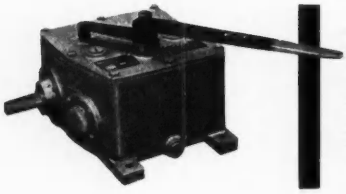

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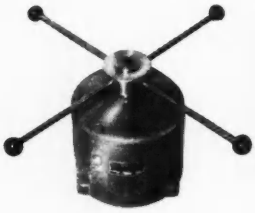

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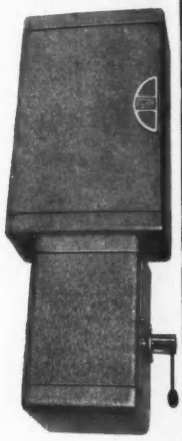

The range has been further reinforced by the production of boards for recessed mounting, illustrated left. They are designed to allow the main body of the board to be sunk into a wall cavity of appropriate depth; the plasterwork and wall finish are then made up to the surrounding surface-plate provided.

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• *NEW OXALATE COATING FOR DRAWING STAINLESS-STEEL TUBES*

A new kind of oxalate coating is claimed to increase the drawing speed of stainless-steel tubes by as much as 300%, and can also be used to advantage in the wire-drawing, deep-drawing, and cold-extrusion of stainless steel. The material used in the process reacts with the metal surface, leaving a fairly hard sponge-like deposit to which lubricants readily cling. On immersion of the stainless-steel tube in the coating bath, free sulphur dioxide, together with hydrogen ions, attacks the surface of the steel, breaking down passivity and taking some of the metal atoms into the solution as ions. This activation disturbs the solubility products of other ions in the phosphating solution. Manganese oxalate, manganese sulphide, and some ferrous oxalate precipitate onto the stainless-steel surface, and other substances like ferrous oxalate separate and become sludge, while ions which have been used next to the stainless steel are immediately replaced from the main body of the bath. Immersion of the tubes in the bath is preceded by cleaning and descaling in a molten caustic salt bath and is followed by rinsing and subsequent coating with a standard lubricant before sending them to the draw benches for reduction. The purpose of producing the inorganic layer on the stainless steel is, of course, to prevent metal-to-metal contact. The coating also acts as a porous surface which is more efficacious in retaining lubricant, thus reducing wear and improving surface finish. Moreover, drawing loads are claimed to be reduced by from 20 to 25%.

• *STATIC EQUIPMENT FOR IMPARTING HIGH SPEEDS TO FLUIDS*

When a stream of liquid or gas emerge sfrom a nozzle fitted with a curved extension in the form of an open channel, it tends to be deflected along the channel in the direction of the curve, so that it is possible to make high streams of fluid literally "go around a corner" without the need to confine it in a closed channel. Furthermore, as a result of this phenomenon, which is known as the Coanda effect, both the mass flow and the velocity of the stream are increased. Utilizing this effect, recently patented equipment, designated a "thermo-blower", is designed to impart a high speed to a fluid, particularly a gas, without the use of any mechanical moving parts, but solely by means of a source of heat. One such thermo-blower is intended to employ the flow of superheated steam through Coanda nozzles for accelerating air in an aircraft jet-propulsion system. A typical propulsion plant of this type could consist of a tubular boiler, and the steam produced would then be raised in temperature by passing it through a superheater coil, whence it would pass under pressure to an air-entrainment system employing the Coanda effect. A particularly interesting feature of this proposal is that not only can the steam be condensed by the accelerated air stream, but also, by separating the condensate from the air, the water can be returned in a closed circuit to the boiler. Provided that the practical difficulties inherent in a scheme of this kind can be overcome, a propulsion plant would be available which would operate without such moving parts as compressors, turbines, etc. It should also be noted that, instead of air, the entrained fluid could be a liquid, such as seawater in the case of a propulsion plant for ships or submarines. In this instance, the fluid to be vaporized would be so chosen that, after condensation of its vapour, its liquid phase would be immiscible with seawater, thus making it possible to separate the two liquids, e.g., by decantation, returning the first liquid to the boiler.

• *NEW ZONE-MELTING PROCESS FOR SEMICONDUCTORS*

A recently patented method of applying the zone-melting process to semi-conductors is based on the discovery that the more closely the structure of a semi-conductor resembles that of a single crystal the more efficient zone-melting purification becomes. In fact, purification is most effective if the semiconductor is an absolutely perfect single crystal. In the new process, which is carried out on a rod of crystallized semiconductor material, such as germanium or silicon, a special device is used for drawing the crystal from the crucible, the zone-melting operation being carried out on the crystal after its removal from the crucible but without removing it from the drawing device. The crystal is held in the vertical position by supporting it at two points as far apart as possible, zone-melting being applied between these two points. This arrangement makes it possible to carry out the melting process on a continuous length of rod, since the support points can be continuously or intermittently moved apart to correspond with the increasing length of the crystal. It is normally desirable to interrupt or to slow down the crystal-drawing process from time to time until the molten zone has been drawn once or several times through a predetermined distance of the crystal rod. However, if an additional drawing device is provided at the lower end of the crystal and if the upper support is moved in the drawing direction, it is possible to carry out the drawing process and the zone-melting process simultaneously. The crystal is purified by moving the melting zone through the drawn crystal from the upper to the lower end, so that impurities are collected in the lower end of the crystal and are absorbed by the mass of the molten material in the crucible.

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THE ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XX No. 4 APRIL, 1959

Health Hazards from Microwave Propagation

By F. LEARY. (From *Electronics, U.S.A.*, Vol. 32, No. 8, February 20, 1959, pp. 49–53, 7 illustrations)

HIGH-POWERED radar, radio, and countermeasure transmitters now being constructed present an element of hazard to health. Thus, new scatter systems are being designed to produce 100 kW of average power, while a proposed torus scanner for a ballistic-missile warning system will beam an average of 600 kW. Similarly, radar equipment, intended for tracking and analysing missile and satellite debris, will also produce an average of 600 kW.

It will be appreciated that the focused concentration of such energy can represent a danger to health; however, like any other hazard, it can be rendered relatively harmless by understanding and precaution. In fact, in the last two years, an intensive research programme has been carried out in an attempt to increase knowledge of the biological effects of exposure to microwaves, and some of the results tend to establish criteria for safety throughout the electronics industry and to indicate several paths for additional research.

EFFECTS OF RADIO-FREQUENCY ENERGY ON ANIMAL TISSUE

Animal tissue reacts to radio frequency in a way comparable to the parallel resistive-capacity circuit shown in Fig. 1. At low frequencies, current tends to bypass the relatively high capacitance of the cell through the conductance of the electrolyte which surrounds it. As the capacitive reactance drops at higher frequencies, the current passes into the cell. At microwave frequencies, reactance drops to the point where animal tissue presents the electrical appearance of a protein solution—a suspension of individual proteins and protein lipoid complexes in an electrolyte.

As frequency rises, the dielectric constant of the cell materials drops, owing to dispersion. In muscle tissue, one drop centres at about 100 cps, while a second and major drop, due to cell structure, centres at about 100 kcps. A third major drop falls in the microwave spectrum at 10,000 to 30,000 Mcps and is caused in part by the properties of biological macromolecules and in part by the water content of tissue. Water is known to display a dispersion near 20,000 Mcps.

The form and orientation of the protein molecules in tissue introduce a complicating parameter, according to research carried out by Schwan at the University of Pennsylvania. The protein constituents appear to leave "dielectric holes" in the electrical path formed by the electrolyte. Fig. 2 illustrates this phenomenon in a 10% solution of haemoglobin in water. The sharp fall-off in dielectric constant in the 1- to 10-Mcps range is part of a major dispersion discontinuity centred around 1 Mcps. If the behaviour of the material were completely described by the 1-Mcps dispersion, the dielectric constant would assume the constant level indicated by the dotted line in Fig. 2. However, the dielectric constant is observed to follow a fairly linear decline, as indicated by the measurement points surrounding the solid line.

Hydration of protein molecules can explain this behaviour. Fig. 3 shows the frequency dependence of the dielectric constants of ice and free water, with the curve hypothetically adduced by Schwan for the bound water which hydrates protein molecules. Ice and water have been thoroughly investigated and are known to undergo dispersion at 1 to 10 kcps and at 20,000 Mcps respectively. A dispersion curve for bound water near 300 Mcps would explain the ultra-high-frequency dispersion phenomena observed in protein molecules.

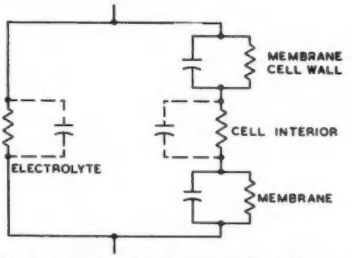

Fig. 1. Equivalent electrical circuit of animal tissue.

The seriousness of the possible effects of radio-frequency energy on living animals depends on several factors, one of which is the size of the animal. Thus, for any significant effect, the animal or part of the animal concerned must be at least 10% of the wavelength in size. Radio-frequency energy generally penetrates between 1% and 10% of its wavelength into living tissue.

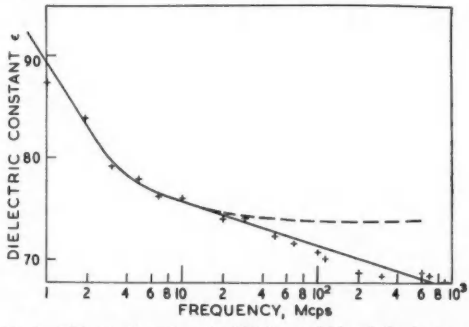

Fig. 2. Dielectric dispersion of a 10% haemoglobin solution in water.

The amount of power absorbed by the body is also frequency-dependent. At frequencies below 400 Mcps and above 3000 Mcps, the body absorbs about half the incident power or less. The rest passes through (lower frequencies) or is reflected at the surface of the skin

(higher frequencies). At frequencies below 1·5 Mcps the human body ceases to be a significant fraction of wavelength. Between 1000 and 3000 Mcps, absorbed radiation can approach 100%, depending on the thickness of the skin and of subcutaneous layers of fat.

Below 1000 Mcps, most radiant energy is translated into heat in the deep tissues (at 300 Mcps, for example, much of the heat would tend to develop three or four inches inside the body). Above 3000 Mcps, the result is mostly surface heating. Intolerable temperature rises are therefore more likely below 1000 Mcps.

The interface effect is an important factor in the biological effect of radio-frequency energy. Every time the energy passes from one material to another, the discontintuity re-orients the power. Power is reflected, and a standing wave results near the interface.

Thermal Effects

Since animal tissue converts into heat most of the electromagnetic energy it absorbs, thermal effects are the most serious recorded thus far. The thermal effects of microwave energy are directly related to average power levels.

The eyes and the testes are the organs most seriously affected by heat, though irreversible damage to the eyes is far more common than irreversible damage to the testes, as the eyes can develop permanent opacities as a result of overheating. Thus, tests on rabbits (whose eyes are closest in structure to human eyes) have shown that small opacities detected after one or a few exposures to radio-frequency energy often develop into major lesions without additional exposure.

Time and power thresholds for lens opacities at 12·3 cm range from 5 min at 0·59 W/cm^2 to 90 min at 0·29 W/cm^2. Exposure to sustained irradiation at 0·12 W/cm^2 for 4·5 hr caused no discernible opacity, suggesting that this power level is a threshold of safe exposure. The 12·3-cm spectrum, i.e., the region between 2400 and 3000 Mcps, has been found critical for the production of cataracts.

Exposure of the whole body is also serious, one of the principal causes of internal damage from natural or induced fever being anoxia, or lack of oxygen. This condition causes almost immediate damage to certain sensitive cell groups in the brain, central nervous system, and internal organs.

Another factor to be taken into consideration is dimensional resonance. Since the body and its parts are conductive, they resonate at critical frequencies and can build up standing waves. Some effects noted in the hollow cavities of the body and in bone marrow appear to have been caused by concentrations of thermal energy that may have been produced by resonance. In more than one case, internal lesions caused by microwave exposure were undoubtedly produced by reflections from fat-muscle or muscle-bone interfaces, giving rise to standing waves in the vicinity.

Experiments with small animals have shown partial or complete loss of control over motor functions under relatively mild exposure, with immediate recovery after removal of power. This effect could result from resonance in the cranial cavity or along the spinal column, possibly creating a strong enough field to beat against and cancel the normal signals in the motor network. The nerve transmission system could thus temporarily be tendered inoperative.

Non-Thermal Effects

Although non-thermal effects have been demonstrated by some investigators, these effects are hard to trace in experiments on animals, since no thermostatic device exists which can keep body temperatures constant and thus eliminate thermal effects. The variability of animal responses also makes it difficult to establish an exact relationship between dose and effect.

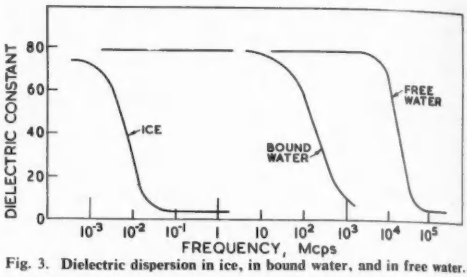

Fig. 3. Dielectric dispersion in ice, in bound water, and in free water.

Molecular response characteristics of protein molecules and protein lipoid complexes may be responsible for non-thermal effects. These responses result from the movement, orientation, and polarization of the molecular constituents, i.e., the side groups and main protein body. Each of the side groups, as well as the main body, may be electrically polar. High radio-frequency strengths can orient the side groups and cause dielectric saturation. When all side groups are completely oriented, the bonds between them and the main protein body may be snapped by a small increase in field strength.

Denaturation of living tissue in this manner, one possible non-thermal effect, is more likely to occur in the 100- to 300-Mcps range. The likelihood decreases sharply above 1000 Mcps. The effect need not have a significant thermal counterpart, since it can be brought about by high peak powers whose average value is not great enough to produce heating.

Non-thermal components have been noted in the production of cataracts, and in variations in blood-clotting time. Indeed, cataracts at subcritical temperatures by exposure to high peak values of power have actually been produced, possibly as a result of molecular responses in the sensitive enzymes. An increase in blood-clotting time may result from similar responses in the thrombocyte platelets.

A clearly non-thermal phenomenon noted is the formation of pearl chains in living fatty tissue, in solutions of erythrocytes, in solutions of milk and blood, and recently in lymph. On exposure to microwave energy, the suspended solids form into chains of round aggregations, similar in appearance to tiny strings of pearls, oriented in the direction of the radio-frequency beam. If such a phenomenon occurs on the molecular level, the natural distribution of tissue components may be disturbed, with a profound biological significance.

Protective Measures

The nature of the problem of biological effects is such that new instruments are needed. Most areas in which the more serious possibilities for damage arise are in the Fresnel zone, just forward of a microwave reflector, and in back-lobes, and from spurious reflections. In the Fresnel-Fraunhofer cross-over and within the Fresnel zone itself, the point-to-point variations in power density are such as to require measurement rather than calculation. Similarly, reflections from buildings and terrain features require measurements, as do back-lobes and transmission-line leaks.

A series of light and portable battery-operated radiometers or power-density meters has already been produced, each meter covering one segment of the microwave spectrum. Dosimeters for personal use by those subjected to possible microwave exposure are also useful items of equipment. One such device contains a broadband transducing material—in this case, a small mass of gelatine, simulating an avascular body structure—for absorbing microwave energy and translating it into heat, and a thermistor for translating the heat into a meter reading. In its present form, the instrument is highly sensitive to ambient temperature; thus, when moved from indoors to outdoors, from table-top to the hand, or even from one pocket to another, it produces a larger change in reading than that caused by a biologically significant radio-frequency field. As a result, it can be rendered ineffectual in use.

This dosimeter has a " fast " component due to radio-frequency pick-up in the wiring, which is converted to heat in the thermistor, and a "slow" component resulting from the conversion of radio-frequency energy to heat in the gelatine. In practice, these result in "rate" and "dose" readings. The thermal time constant of the gelatine is about 6 min, i.e., within the range of biological significance.

Protective clothing to absorb or reflect radio-frequency energy is also needed, and the design of such clothing is within the scope of present technology. Of especial importance is headgear for adequately protecting the eyes. Glasses may cause more trouble than they prevent, especially if they are prescription lenses. By reflecting and focusing radio-frequency energy, they might cause the build-up of nodes and standing waves just where they can do the most harm. An efficient head covering would have to block out all access to the rear aspect of prescription-type glasses, and would of necessity include a planar eyepiece of transparent material for users who do not wear spectacles.

U.S.A.

Automatic Transfer Line for the Production of Typewriter Power-Frames

STATED to be the first application of its kind to the production of typewriter components by automation techniques, a new pallet-type " Transfer-matic " automatic transfer line, designed and constructed by the Cross Company, of Detroit, is currently being used to turn out aluminium die-cast power-frames for typewriters at the plant of an American business-machine company. The frames, one of the most delicate parts ever produced in a transfer machine, are completely processed, 106 broaching, milling, drilling, reaming, spot-facing, chamfering, and tapping operations being performed on each part. The capacity of the line exceeds 150 frames per hour.

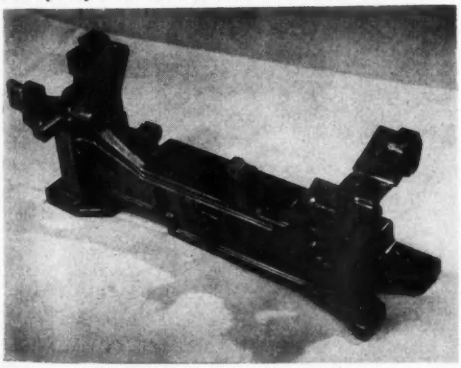

Fig. 1. Aluminium typewriter power-frame.

From the point of view of part rigidity and fixture design, these frames (Fig. 1) obviously presented serious problems with regard to efficient precision production. Furthermore, tolerances for several of the parts were required to be held closely. Thus, tolerances for the carriage support-rail seats are maintained in plane to within 0·001 in., for overall length to within 0·003 in., for the shaft holes in line from end to end to within 0·001 in., for the hole locations relative to milled surfaces to within 0·003 in., and for the four broached spring seats in plane to within 0·005 in. To achieve these high tolerances, parts are processed in the transfer line in two-position pallets (Fig. 2) incorporating special power-clamping fixtures, each part being carried twice from the loading station through ten machining stations in two positions. Initially, the part is processed in the *A* position (at the left of Fig. 2), with the top, bottom, and back sides exposed to the machining units. In the second trip, the part is clamped in the *B* position (at the right of Fig. 2), with the ends exposed to the machining units.

Part clamping is critical, since the slightest over-clamping results in distortion. Consequently, the frames are secured in the pallet fixture by specially designed spring-loaded clamps, individually adjusted initially for exact spring tension. All clamps are designed and located to compress on the more robust portions of the metal. Power for clamping and unclamping is provided by a separate hydraulic mechanism at the load-unload station,

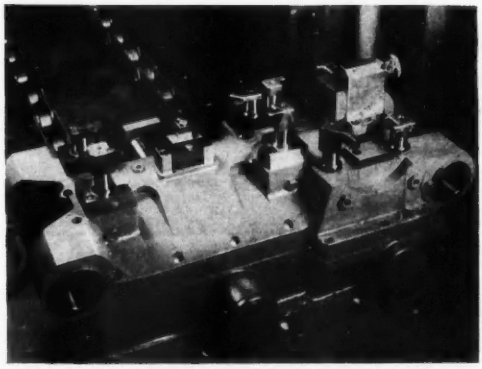

Fig. 2. Two-position pallet used for machining power-frames.

which actuates a spring-plate device in the pallet for raising and lowering the clamps.

In the *A* position, the part is centrally located in the pallet by a fixed pin which engages a centrally cast hole in the part. Location in the horizontal plane is accomplished by four points, two of which are equalized to produce the proper plane. Parts loaded in the *B* position locate off four stepped rail seats, previously rough- and finish-milled in the *A* position. The part is centralized in the same way as in position *A*.

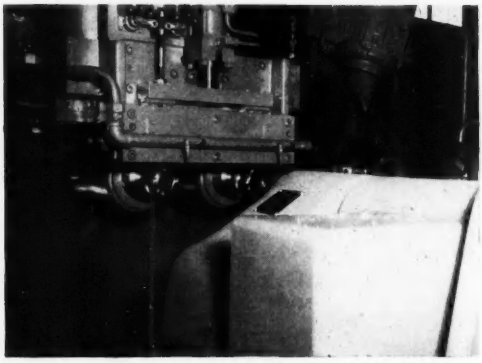

Fig. 3. Two-spindle milling head used for finish-milling the power-frame rail seats.

Additional support for finish-milling the rail seats at station No. 3 is provided by a special clamping unit mounted on the two-spindle milling head (Fig. 3). When the pallet is located and locked in the work station, two sets of spring-loaded locking jacks in the clamping unit descend, and engage and hold the rail-seat lugs securely during the milling cycle, no actual clamping pressure being applied by the jacks. By providing rigid support on each side of the lugs, deflection, vibration, and chatter under cutting pressures are prevented.

Transfer and approximate locating of the pallet are accomplished by a transfer bar. Final location of the pallet in the work station is effected by means of shot pins which, as they enter the locating holes, simultaneously cause the pallet to be locked.

The complete transfer line is illustrated in Fig. 4. In the first section, consisting of five machining stations, six rough- and finish-milling operations, and a total of forty-seven horizontal and vertical drilling, reaming, spot-facing, and tapping operations are performed on the parts in both positions. Pallets are then transferred by a standard chain-type conveyor to the second section, where four angular broaching operations and a total of forty-nine drilling, reaming, and tapping operations complete the machining cycle. Following these operations, the pallets are transferred through a blow-off booth, where the parts are air-cleaned, after which they are returned by a conveyor to the load-unload station at the head of the first section.

Two precision in-line drilling and reaming operations performed at stations No. 4 and No. 11 require special "snorkel-type" travelling guide bushings to prevent the tool from wandering between holes. In both cases, the holes machined are widely separated and must be held in line to within 0·001 in. end to end. In both stations special hydraulically actuated mechanisms mounted over the machines descend and position drill bushings when the pallet is located in the work station. All four spring seats are broached simultaneously in a single pass by a broaching unit at station No. 11.

To minimize distortion and deflection of parts during machining, high cutting speeds are employed, with fine feeds to reduce cutting pressures. In addition, this combination produces the fine finishes required.

By the use of a machine-control unit, programmed tool changes reduce down-time to a minimum. Where applicable, all tooling is of the quick-change, preset type. To prolong periods between tool changes, machining operations are flooded with coolant from a central coolant system.

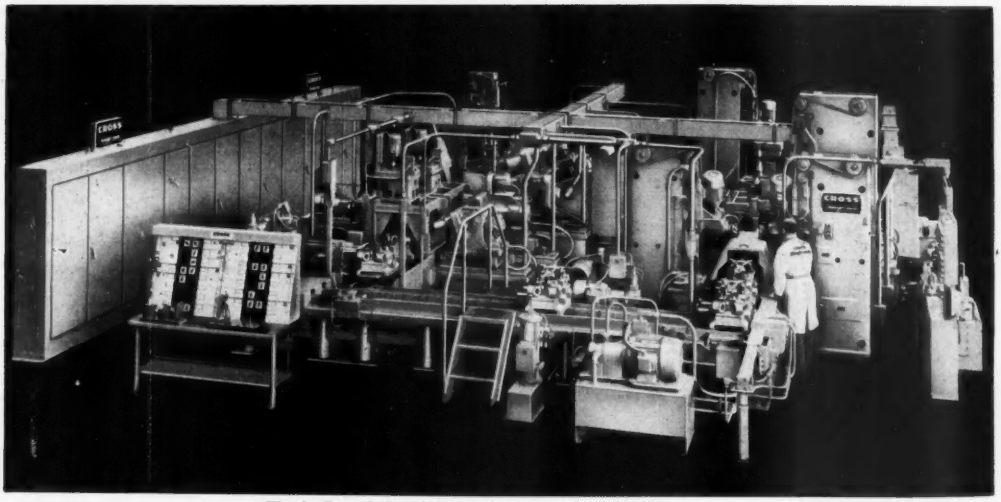

Fig. 4. General view of the complete automatic transfer line.

For operation at a peak capacity of 156 frames per hour over extended periods, an auxiliary load-unload station is provided at station No. 14 at the end of the second section. When this station is in use, a second operator can assist in unclamping and removing or repositioning parts in the pallets.

Noise Problems in Large Transformers

By E. Reiplinger. (From *Siemens Zeitschrift*, Vol. 33, No. 2, February 1959, pp. 69–76, 14 illustrations)

The increasing demand for power, resulting in the introduction of high-voltage lines into towns and the erection of outdoor transformers in residential areas, emphasises the requirement for low-noise transformers.

The primary source of transformer noise is the magnetostrictive vibration of the iron core. The leakage field and the electromagnetic forces between the individual turns of the coils also contribute to the noise level, but to a much lesser extent. Magnetostriction occurs cyclically, with a magnetostriction loop which is a function of flux density (Fig. 1a). The vibratory strain in the metal reaches peak amplitudes at both positive and negative maxima of flux density, so that the vibration frequency is twice the excitation frequency. At higher values of magnetic induction approaching the saturation limit of the transformer laminations, the magnetostriction loop becomes distorted, as in Fig. 1b. The distortion increases the number of harmonics which cannot be neglected, not only raising the noise level but also shifting the noise spectrum towards a higher-frequency region. In other words, with a mains frequency of 50 cps, the core acts as a noise generator, with a basic frequency of 100 cps and appreciable harmonics up to about 600 cps.

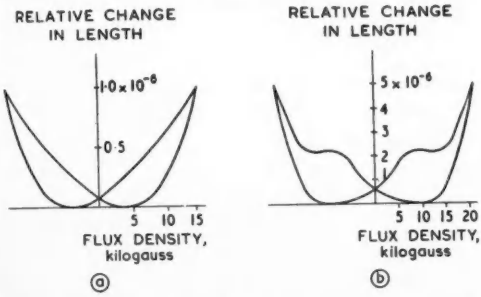

Fig. 1. Magnetostriction loops of grain-oriented transformer sheet. (a) Up to 15 kilogauss. (b) Up to 20 kilogauss.

The vibrations are transmitted to the transformer tank, either directly or through the oil surrounding the core, the oil behaving practically as an incompressible medium, though it provides some damping, owing to its viscosity. The tanks and the various items of equipment attached to it transmit these vibrations, as well as those due to their own resonant frequencies, to the surrounding air. To limit noise, it is therefore important to study both air-borne noise and structure-borne noise, i.e., mechanical vibrations, originating at the core.

Measurements of Transformer Noise

To determine the operating conditions of transformers, the air-borne noise was measured with a German standard noise-meter, while the structure-borne noise was indicated by means of suitable vibration pick-ups.

As transformers are set up in very different surroundings, it is not possible to compare noise spectra of various types if each is measured on site. Consequently, noise measurements of a considerable number of large transformers were made in the open air under identical environmental conditions, before the transformers left the works. The various tests carried out in each case were as follows:—

(1) Determination of sound-level contours in the open air, at a position midway up the transformer tank and at a distance of 3 metres from one side.
(2) Loudness measurements as functions of magnetic induction, so as to be able to compare transformers with cores having different induction, and also to determine the resonant frequencies excited by harmonics at high saturation values.
(3) Frequency analyses of air-borne noise, to determine its nuisance value, as it is recognized that noise is more troublesome when it contains a considerable number of high-frequency harmonics.

The method of measurement employed was based on the new VDE draft specification on transformers. For prototype investigations, the VDE method yields accurate data on the noise spectrum, whereas tests on mass-produced transformers are confined to measurements at a short distance for a very simplified determination of noise levels. The special feature of this specification is that only one frequency-correction curve is used for all noise levels, whereas in German standard noise-meters, with compensating circuits inserted between the microphone and the noise-measuring circuit, two curves are employed, i.e., a fairly flat curve (No. 1) for loudnesses above 60 standard phons and a steeper curve (No. 2) for loudnesses below this value.

Transformer noise consists mainly of very low frequencies, and these curves mainly affect the very low and the very high frequencies. In switching over from one compensating circuit to the other, small changes in sound level are then indicated by the noise-meter as considerable variations in loudness. As most of the loudness values to be considered are below 60 phons, it has been proposed that only the steeper curve (No. 2) should be used. This means that, for measurements at positions close to large transformers with loudnesses above 60 phons, the values obtained will be 6 to 10 dB lower than those previously quoted. Consequently, at the present transitional stage, it is necessary to specify which curve has been used.

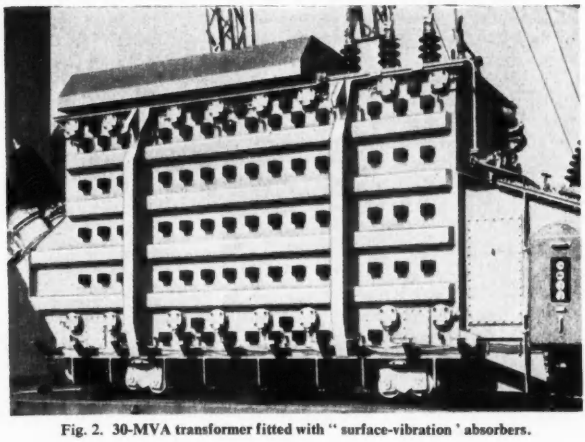

Fig. 2. 30-MVA transformer fitted with " surface-vibration ' absorbers.

Methods of Reducing Transformer Noise

The noise level of transformers depends not only on the value of magnetic induction and the magnetic properties of the core laminations, but also on the dimensions and shape of the core. Increased values of induction cause greater magnetostrictive changes in length. At higher ratings, the core dimensions become larger and also result in greater changes in length. Moreover, the sound-radiating surface is increased correspondingly. In principle, it is possible to limit the magnetostrictive vibrations of the core laminations by reducing the induction, but this would be an expensive solution. Also, the noise generated at the core might be reduced by special modifications but, up to the present, it has not been possible to produce sheets with sufficiently low values of magnetostriction, combined with the other magnetic properties required for transformers.

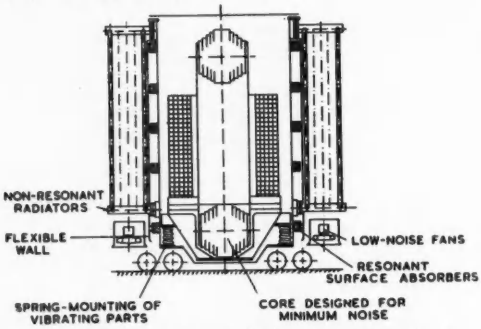

Fig. 3. Schematic arrangement of a large low-noise transformer.

The vibratory behaviour of the individual components of transformers has been investigated in detail over a number of years. As a result, various methods of noise reduction have been developed for large transformers. In this connection, the iron core, as the primary source of vibrations, has been investigated. Although the magnetostrictive action cannot be reduced, it has been found possible to limit the amount of sonic power transmitted from the iron core by design modifications and manufacturing procedures.

Core vibrations are transmitted partly through the oil and partly by direct contact between the core and the tank. Some noise reduction can therefore be obtained in principle by interrupting the paths of the vibrations. Structure-borne noise between the core and the tank has been isolated by mounting the vibrating elements on steel springs transmitting only 2% of the vibration. Interruption of the sonic paths through the oil has presented very considerable difficulties. Thus, a proposed arrangement using air as the sound-absorbing medium, enclosed in relatively soft material, has been shown to be quite impracticable, owing to the high capital cost involved. Furthermore, the presence of air layers of any kind in the tank can constitute a danger to operational safety and can exercise an adverse effect on cooling conditions.

Structure-borne noise is transmitted to the surrounding air by the tank, so that it is necessary to reduce tank vibrations. A very rigid tank construction (with thick external ribs in the vertical and longitudinal directions) has been developed, and this has reduced the ability of the walls to vibrate at low frequencies. In addition, vibrations of the tank walls have been damped by external means. For this purpose, absorbers of structure-borne noise have been developed, their purpose being to dissipate the energy of vibrations of the tank. These "surface-vibration" absorbers are square-shaped pads of rubber, fixed to the tank walls and tuned to resonate at one of the main frequencies of the wall, i.e., at 100, 200, or 300 cps for transformers excited at 50 cps. The free ends of the absorbers vibrate with considerably greater amplitudes than the tank itself. Their damping effect is due to the continuous conversion of vibratory energy into hysteresis work in the rubber. The pads are bonded to iron plates which are screwed onto the walls of the tank, as can be seen in Fig. 2. Up to six or seven rows of such pads are used on the flat surfaces between the reinforcing ribs, the horizontal distance between the pads being about 1½ times the length of one side of a pad. Some of the pads and spring mountings used are shown in the schematic arrangement in Fig. 3.

Air-borne noise is further reduced by fitting thin sheet-metal outer panels on both sides of the tank. As can be seen from Fig. 4 three such plates, of fairly large dimensions, are fitted along the sides of the two main vertical ribs of the tank, and are attached to the top and bottom of the tank by anti-vibration mountings. The plates are situated between, and are clear of, the tank wall and the radiators. To some extent these plates also act as sound barriers; they reduce the degree of coupling between the tank surfaces and the air, because, whereas the tank frequencies are fairly low, the flexural frequencies of the plates are much higher, so that less noise is radiated.

The cooling elements of the radiators are also liable to vibrate. By suitable design changes, e.g., banks of radiator tubes of gradually increasing height (Fig. 5), resonant frequencies are altered in such a way as to be out of the range of excitation of the transformer vibrations. In this manner, radiator noise is eliminated, and the overall noise levels of the transformers are about the same with and without the radiators.

To overcome the noise of the cooling fans, special low-noise designs have been developed. Operating at a speed of only 750 rpm, these fans provide particularly good air-flow conditions, so that fan noise can now be lower than the noise level of the transformer.

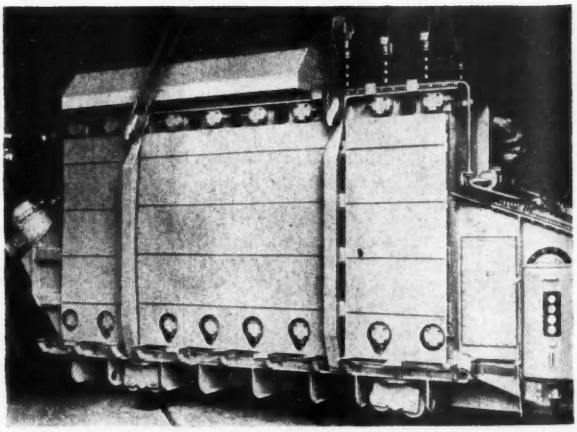

Fig. 4. 30-MVA transformer fitted with sheet-metal panels for noise reduction.

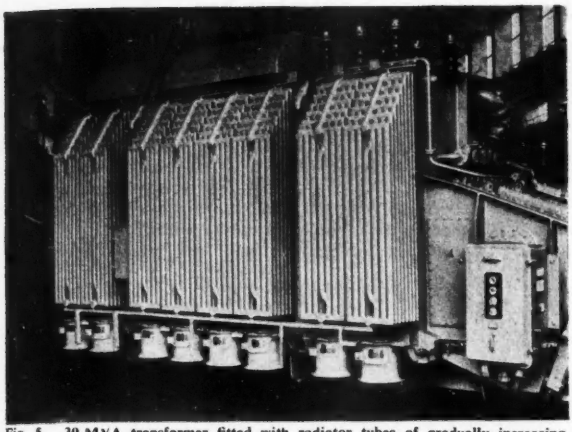

Fig. 5. 30-MVA transformer fitted with radiator tubes of gradually increasing height, to eliminate their excitation by transformer vibrations.

Results of Measurements

The loudness levels of the modified transformers were measured at various stages during manufacture, and reductions in noise were obtained in each instance. The loudness curve of a 30-MVA, 110-kV transformer, for example, determined as a function of distance, indicated 67 dB at 1 metre, 63 dB at 3 m, and 54 dB at 12 m. In this transformer, the modification to the core accounted for a noise reduction of 5 dB at 3 m. The redesigned tank was responsible for a further reduction of 9 dB. At greater distances, the noise reduction was even more pronounced. Thus, the noise level of this new transformer is about 14 dB lower than that of the previous design.

Furthermore, the subjective impression of the noise was improved by practically isolating the fundamental tone at 100 cps. This noise now appears as a low-frequency hum which is not troublesome to the human ear. The small second and third harmonics, at levels 10 and 17 dB lower, are hardly noticeable. The fan noise, about 12 dB lower than that of normal fans, can no longer be singled out, even at a fairly short distance.

The special low-noise transformers which have been described are now being produced for power ratings up to 60 MVA. Depending on the rating and the allowable expenditure, noise reductions of at least 5 to 15 dB relative to previous designs have been obtained. There is a need for such transformers in residential areas, where, according to the latest recommendations, the loudness level should not exceed 40 phons at night. If an unsilenced transformer with a loudness of, say, 75 dB at 3 m distance is considered, the distance between the transformer site and the nearest house would have to be 150 to 200 m, which is often impossible. With a low-noise transformer giving 65 dB at 3 m, this distance can be reduced to 50 m. Even greater reductions in noise level can be obtained at a correspondingly greater cost. At very high ratings, the large cooling fans are the main source of noise; however, considerable improvements in this respect can be expected in the near future.

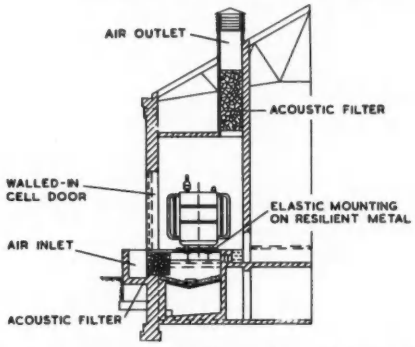

Fig. 6. Arrangement of a 20-MVA transformer in an acoustically treated cell.

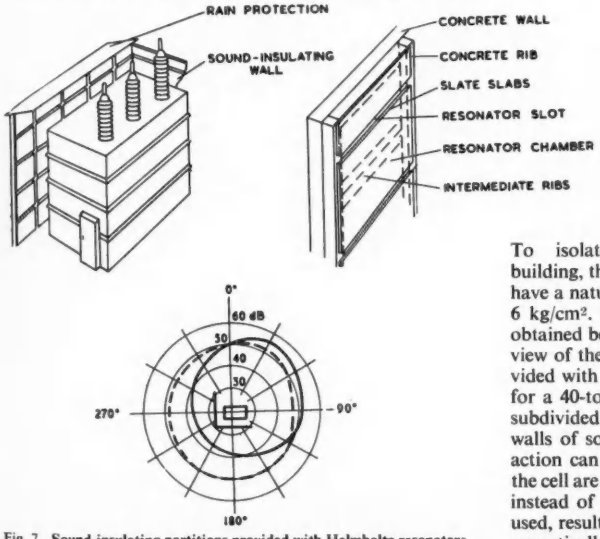

Fig. 7. Sound-insulating partitions provided with Helmholtz resonators, and polar diagram of noise distribution with screening (full line) and without screening (dotted line).

Additional Measures on the Transformer Site

In particularly unfavourable cases, it may be necessary to set up the transformer in an acoustically isolated cell (see Fig. 6). To isolate the structure-borne noise from the building, the transformer is placed on resilient rails which have a natural frequency of 8 cps at a surface pressure of 6 kg/cm^2. In this manner, an attenuation of 45 dB is obtained between the transformer and its foundation. In view of the cooling requirements, the cell has to be provided with large air inlet and outlet openings, e.g., 9 m^2 for a 40-ton 20-MVA transformer. These openings are subdivided into individual chambers by intermediate walls of sound-absorbing material. The noise-damping action can be predicted fairly accurately. The walls of the cell are also provided with sound-absorbing materials; instead of these, however, Helmholtz resonators can be used, resulting in even greater noise reductions. With the acoustically treated cells, the noise reaching the outside is attenuated by 15 to 17 dB.

Where large transformers have to be set up in the open air, sound-insulating partitions can be used in the directions particularly sensitive to noise. The partitions can be arranged either all round the transformer or on two or three sides only. Partitions about 2 m higher than the upper edge of the transformer are sufficient to obtain substantial improvement. The condition of the inner surface of the partition is of importance, since smooth walls reflect sound and lead to increased noise levels in the directions where no noise barriers are provided. The use of sound-absorbing materials on these inner surfaces is not practical, since these surfaces are exposed to the weather. However, since the transformer noise consists of a small number of discrete frequencies, the partitions can be made so as to incorporate Helmholtz resonators.

As shown in Fig. 7, such partitions consist of an outer wall of concrete with vertical and horizontal ribs on its inner surface. Slabs of slate are placed on these ribs, with a horizontal slot between them, constituting the resonator orifice, while the lower cavity between one of the slabs and the outer wall forms the resonator chamber. The attenuation can be predicted by calculation. Noise reductions of 10 to 15 dB can thus be obtained, even at a greater distance from the wall.

U.S.A.

Silver-Plated Aluminium Bus-Bars

By C. E. Burley. (From *Power Apparatus and Systems* (*A.I.E.E.*), No. 39, December 1958, pp. 1024–1028, 6 illustrations)

The advantages of aluminium over copper and other metals as an electrical conductor are well known, and have given aluminium cable an undisputed lead in electrical transmission systems and have increased its use in distribution systems.

The extensive use of aluminium for bus-bars is a comparatively recent application. In this connection, it should be appreciated that the most persistent problem in the application of aluminium bus-bars has been that of making reliable electrical connections with simple and inexpensive techniques. Poor electrical connections are related to the natural oxide film on the surface of the aluminium and to the possibility of galvanic corrosion in aluminium-copper connections. It is known that, for many types of service, these problems may best be overcome by surfacing the aluminium with a high-quality silver plating. Unfortunately, however, the commercial availability of silver-plated bus-bar has been limited, mainly because it is more difficult to apply a quality silver-plating to aluminium than to copper. Thus, while silver can be plated directly onto a clean copper surface and, in fact, it is common practice to " brush-plate " only those parts of a copper bus-bar to be used as contact surfaces, a quality silver-plating cannot normally be deposited directly on aluminium, and brush-plating methods are generally unsatisfactory.

With the above considerations in mind, research has been conducted in the U.S.A. by the Reynolds Metals Company for the past two years to develop a commercial process for silver-plating aluminium bus-bar material. The recent successful culmination of this research has lead to a manufacturing process in which adherent layers of zinc, copper, and silver are successively deposited on aluminium bus-bar which has been previously surface-conditioned. Although the plating process has been developed for rectangular 6101-alloy material in both the T6 and T62 tempers, it is applicable to other shapes and to other aluminium alloys.

Two principal factors which determine the process steps for silver-plating aluminium are the selection of a pretreament which removes the surface aluminium oxide, and the choice of metals for the intermediate layers which will provide corrosion protection. The goal of the research programme was to develop a single product that could be used economically in a maximum number of applications. Exploratory study showed that multi-layer zinc-copper-silver plating offered the most promise for a satisfactory product. Other plating combinations were investigated, and some showed advantages for special applications.

Complete removal of aluminium oxide is necessary to ensure good adhesion of the subsequent metal layers and to reduce the surface contact resistance. This removal of the oxide destroys the natural corrosion resistance of the aluminium. As the final step in the surface-conditioning process, a thin coating of zinc is applied to the bare aluminium to eliminate re-formation of oxide. To protect the aluminium, a pore-free coating of metal must be used over the aluminium. Since silver is expensive, it is more economical to plate another metal, such as copper. This copper plate is followed by a thin plating of silver, whose thickness is now determined by its abrasion characteristics, and not necessarily by its porosity.

The process developed consists of nineteen steps, including surface conditioning of the bare aluminium, deposition of zinc by chemical displacement, electrodeposition of copper and of silver, and coating with a tarnish-resistant finish. The final coating, used only to minimize tarnishing of the silver during handling and shipping, need not be removed before installation. For outdoor and severe corrosive environments, additional protective coatings, such as paint, should be applied.

Quality control of the plating process is maintained by periodic chemical analyses of the plating solutions. In addition to process controls, a performance type of specification, incorporating appropriate production control testing procedures, was developed to assure finished platings of uniform high quality. These specifications were developments of an evaluation programme, based on the chemical, electrical, and mechanical properties of plated bus-bar which could be produced economically on a commercial scale. Comparison was made of several plating techniques in which the process variables were controlled over wide ranges. Results were judged by the absence of blistering during and after the plating operations; the uniformity of colour and appearance; measurements of joint resistance before and after accelerated corrosion; determinations of the temperature rise of joints during current loading; the formability of plated bus-bars in bend tests; the abrasion resistance of platings; and the corrosion resistance of flat and bent areas in accelerated water-fog-spray tests.

The basic requirements laid down by the research laboratories can be summarized as follows:—

(1) There must be excellent adhesion between the plating and the base metal, the reason being, of course, that a plating which might blister or peel off under service conditions would be worse than useless.

(2) The plating must be free from porosity. This is important, because ordinary platings on aluminium tend to be porous, and the existence of pores could lead to corrosion of the aluminium under certain conditions.

(3) The plating must have good resistance to abrasion, to ensure that it will remain intact, even though " wiping " contacts may be repeatedly made.

(4) The plating must have maximum formability consistent with other requirements, so that forming operations can be performed without danger of peeling.

The results of this programme indicate that the process is a satisfactory method of producing silver-plated aluminium bus-bar material. The electrical character-

(*Concluded on page 153*)

SWITZERLAND

Special-Purpose Accessories for Spot-Welding Machines

By El. Ing. W. Wetli

The fact that resistance welding can often achieve a substantial economy in production costs is being increasingly appreciated in Europe. The designer of resistance-welding equipment is therefore confronted not only with problems concerned with the development of improved resistance-welding machines, but also with the development of suitable accessories for increasing production.

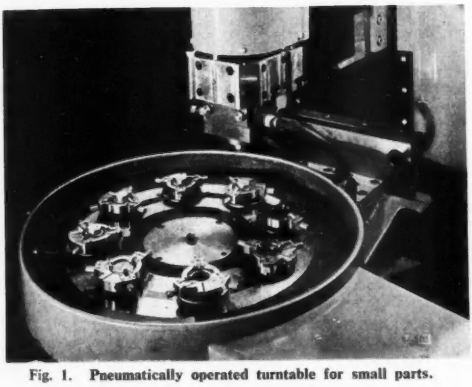

Fig. 1. Pneumatically operated turntable for small parts.

With modern machines incorporating electronic control for programming current and pressure, the duration of the welding process is largely determined by the nature of the application concerned. It should be understood that the modern tendency is towards welding times of short duration and the use of high currents, and spot-welded joints made in this way exhibit high strength. However, powerful machines are required for this purpose, and any attempt to increase production still further by reducing welding times is hardly likely to be successful. On the other hand, considerable gains in overall production time can be achieved by more efficient means of loading and unloading of the components to be welded, by the automatic positioning of workpieces, and by the use of multi-electrode spot-welding techniques and projection welding.

To be able to utilize existing welding plant to the best advantage, it is therefore necessary to incorporate suitably designed accessories to reduce non-productive times to a minimum. At the same time, however, the cost of such accessories must be in reasonable relation to the capital cost of the entire plant, if their installation is to be economically justified.

A turntable is often a convenient means of permitting parts to be loaded, positioned, and unloaded continuously, with loading and possibly unloading being accomplished during the actual welding cycle. An example of the use of such a turntable is shown in Fig. 1. This particular table is pneumatically actuated and is used in conjunction with a heavy spot-welding machine, capable of providing welding currents up to 80,000 A and a pressure of about 9000 lb. The parts, in this case the top and bottom covers of transistor elements, are loaded by hand, ejection being automatic. Spot-welding is in the form of an annulus and seals the element hermetically.

Another turntable for the loading, positioning, and unloading of small parts is shown in Fig. 2. With this turntable, which is mechanically operated by a cam, loading is again carried out by hand, and ejection is effected either mechanically or pneumatically. In many cases, loading can also be an automatic operation, using a suitable magazine or hopper fitted with a magnetic sorting device and a feeder mechanism.

For large components which are not easy to handle, a turntable is generally unsuitable, and in its place a bench can be provided, as in Fig. 3, which shows a jig

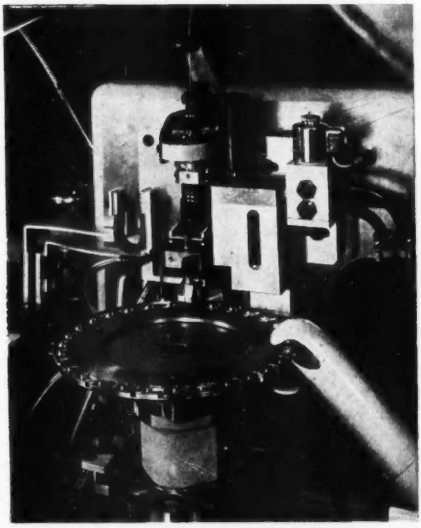

Fig. 2. Mechanically operated turntable for small parts.

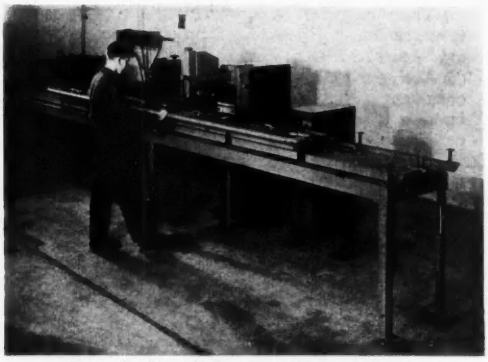

Fig. 3. **Bench and jig for spot-welding textile frames.**

used for welding textile frames. The frames, in which 63 spot-welds have to be made, are held in position by toggles, and the feed mechanism and the electrode are interlocked, so as to ensure that the electrode cannot descend unless the carriage holding the frame is in the correct welding position. Movement of the table, both longitudinally and transversely, is effected by hand.

Several automobile manufacturers are now using spot-welding techniques for attaching the rims of motor-car wheels, instead of the arc-welding technique previously used. To ensure high-quality joints, heavy machines, producing single spot-welds, are employed. For convenient manipulation of the wheel during welding, a rotating fixture, such as that shown in Fig. 4, is used. The wheel is firmly gripped in the fixture, which also constitutes one of the electrodes, and welding is initiated by depression of a pedal. The welding cycle is automatic, i.e., the wheel is rotated from one position to the next, a total of twelve individual spot-welds being made.

Spot-welding with a conventional machine can often be used in the production of such items as wire grilles and fencing. As in the case of projection-welding, a number of electrodes in parallel are provided for simultaneous welding of the points of intersection of the wires.

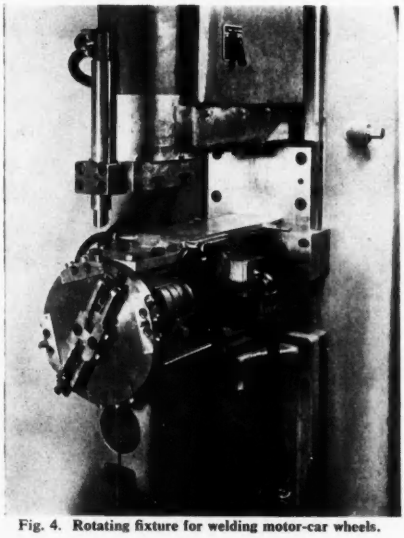

Fig. 4. **Rotating fixture for welding motor-car wheels.**

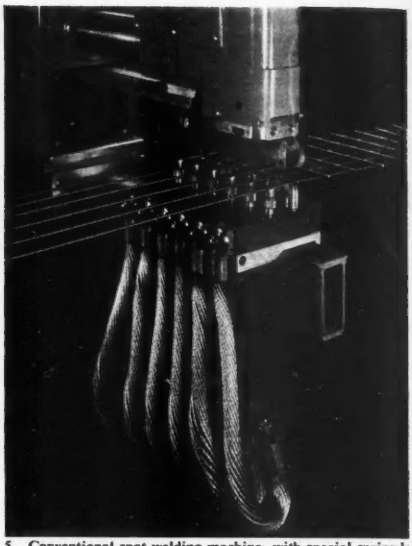

Fig. 5. **Conventional spot-welding machine, with special spring-loaded electrodes, for cross-wire welding.**

However, as the magnitude of the welding current at each point is dependent on local resistance conditions, it is desirable that the contact pressure at each point should be uniform. For this purpose, the lower electrodes are individually spring-loaded, as shown in Fig. 5, and, if desired, loading and feeding can be made automatic, as is the case with machines specially designed for this purpose.

In many cases, it is not possible to use conventional spot-welding machines for stud-welding, as suitable fixtures for holding the studs in a vertical position are not provided. Fig. 6 shows a design of a pneumatically operated clamping device which is suitable for a wide range of stud sizes and which can be used in conjunction with any pneumatically operated spot-welding machine.

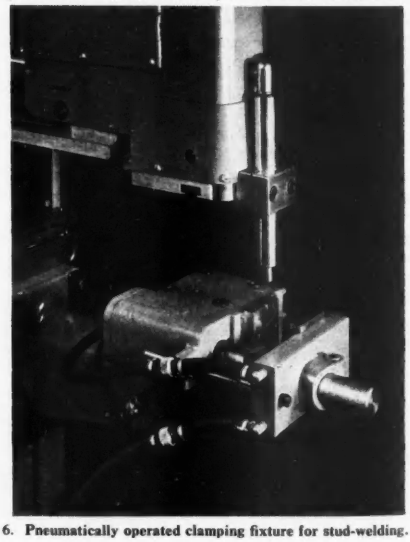

Fig. 6. **Pneumatically operated clamping fixture for stud-welding.**

Combustion Knock and Related Flame Velocity in Otto-Cycle Engines using Hydrogen/Air Mixtures

By R. O. KING, S. V. HAYES, A. B. ALLAN, R. W. P. ANDERSON, and E. J. WALKER. (From *Transactions of the Engineering Institute of Canada*, Vol. 2, No. 4, December 1958, pp. 143–148, 7 illustrations)

THE use of hydrogen as a fuel for Otto-cycle engines gives rise to difficulties that are not encountered when petrol or natural gas, which contains methane in a concentration of 96% approximately, is used in similar conditions of operation, and many schemes have been proposed for the use of hydrogen in mixtures with air or oxygen for such engines. This paper details the results of a continuation of experiments on the combustion of hydrogen at compression ratios of 12:1 and higher, using a Co-operative Fuel Research (C.F.R.) engine with a modified cylinder and piston.

In the modified C.F.R. engine, overlapping of the spark-plug holes by the top ring of the piston, even at a compression ratio of 20:1, was avoided by using 14-mm., instead of 18-mm, spark plugs and by increasing the width of the land above the top piston ring. In addition, the piston was fitted with five narrow pressure rings, instead of the four wider rings of the standard piston, in an endeavour to reduce the rate of oil passing the piston. The number and arrangement of spark-plug holes in the wall of the C.F.R. standard and the modified cylinder are shown in Fig. 1. The gaseous mixture was always ignited by a single spark plug in the position shown, and spark timing was always adjusted to that required for maximum power. The exhaust valve was of the sodium-cooled type, and the temperature of the hydrogen/air mixture and that of the jacket coolant were always maintained at 65°F. A single variety of synthetic lubricant was used, the temperature of the lubricating oil in the crank-case sump being maintained at 140°F by an external electric heater with manual control.

All tests were carried out when the engine had been fitted with a plain inlet valve. This type was used for the purpose of avoiding the reduction in volumetric efficiency and power output consequent on the use of the shrouded valve, as specified for knock rating.

Tests were carried out at compression ratios of 12, 14, 16, 18, and 20, and at speeds of 1200, 1500, and 1800 rpm, using hydrogen reputed to be 99·5% pure and with an assumed lower calorific value of 274·5 BTU/cu ft at 60°F and 30 in. Hg. The cylinder was removed after every test for inspection of possible carbon deposits. The surfaces of the combustion space and the piston, including the rings and their grooves, were always found to be clean. There was then no backfiring or detonation and no pre-ignition attributable to carbon deposits.

MAXIMUM INDICATED THERMAL EFFICIENCY AND RELATED DATA

Table I shows maximum values of indicated thermal efficiency (I.T.E.) related to speed, compression ratio (C.R.), mixture strength (M.S.), optimum spark timing (O.S.T.), indicated horsepower (I.H.P.), indicated mean effective pressure (I.M.E.P.), and volumetric efficiency (V.E.). With regard to mixture strength, it should be noted that mixtures with air are described as per-cent weak or rich, according to the percentage by which the ratio of hydrogen to air volume is less or more than that required for a chemically correct mixture, i.e., 0%.

TABLE I : MAXIMUM VALUES OF INDICATED THERMAL EFFICIENCY AND RELATED DATA

Speed [rpm]	I.T.E. [%]	C.R.	M.S. [% weak]	O.S.T. [deg.]	I.H.P.	I.M.E.P. [psi]	V.E. [%]
1200	45·3	12	51	18	5·68	100	88
1200	46·4	14	52	18	5·66	100	87
1200	47·3	16	52	18	5·75	101	85
1200	47·9	18	52	15	5·79	102	86
1200	48·2	20	52	10	5·75	103	85
1500	46·4	12	56	25	6·64	93·6	88
1500	46·9	14	56	25	6·71	94·7	88
1500	48·4	16	57	22	6·97	98·3	89
1800	48·0	12	64	31	6·39	75·2	80
1800	49·3	14	64	30	6·52	76·8	80
1800	50·6	16	64	28	6·68	78·8	80
1800	51·3	18	61	25	7·25	84·5	81
1800	51·7	20	61	20	7·42	87·5	81

The data in Table I show that the mixture strength required for maximum indicated thermal efficiency diminishes with an increase in speed, while remaining nearly independent of compression ratio at any particular speed. Compression ratios rising to 20 were usable at speeds of 1200 and 1800 rpm, but the highest usable compression ratio was 16 at a speed of 1500 rpm, this limit being fixed by the onset of pre-ignition. At 1200 and 1800 rpm, the values of indicated thermal efficiency were consistent with increases in compression ratio and decreases in mixture strength. The values of indicated thermal efficiency at 1500 rpm for a mixture 56% weak were, however, not consistent with those at 1200 rpm for a mixture 52% weak.

The out-of-line values for indicated thermal efficiency at 1500 rpm, and the occurrence of pre-ignition at compression ratios higher than 16, are attributed to effects arising from the change in valve timing made when speed was increased from 1200 to 1500 rpm. A low-speed camshaft was used for trials at 1200 rpm,

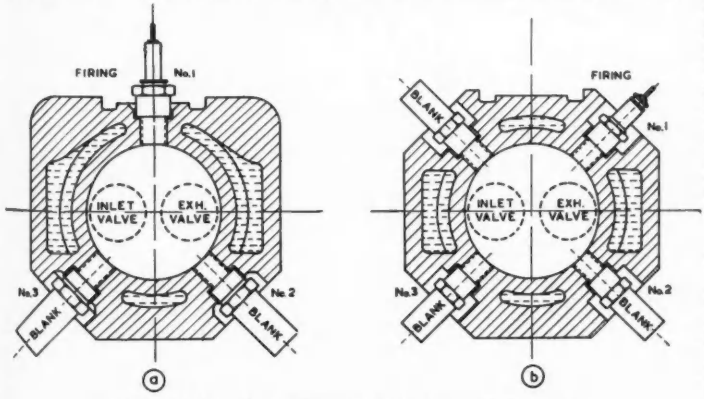

Fig. 1. Positions of spark plugs and blank plugs on (a) the standard C.F.R. cylinder, and (b) the modified cylinder.

and provided for the closing of the inlet valve as the exhaust valve was opening. A high-speed camshaft was used for trials at 1500 and 1800 rpm, and provided for both valves being partly open for nearly 30 deg. of crank revolution and for a greater maximum opening. Thus, it is shown by the data in Table I that the valve timing provided by the high-speed camshaft was more suitable for a speed of 1800 rpm than for one of 1500 rpm.

Maximum Indicated and Ideal Thermal Efficiencies

The tests showed that the mixture strength required for maximum indicated thermal efficiency at a particular engine speed remained nearly constant as compression ratio was raised from 12 to 20. Fig. 2 shows thermal efficiency as a function of compression ratio at speeds of 1200 and 1800 rpm and with mixture strengths of 63·5% weak and 52·0% weak, the indicated values being shown by curves *A* and the calculated ideal values by curves *B*.

The calculation of the above ideal values was based on the method proposed by Leah[1], allowance being made for dissociation, for changes in the specific heat of the working fluid with temperature, and for the volumetric contraction occurring from the combustion of electrolytic gas. The indicated values depend, in addition, on engine speed, valve timing, and the loss of heat from the working fluid to relatively cool surfaces. This loss is of special importance when hydrogen is used as an engine fuel, because of the low value of the volumetric heat of combustion of the weak mixtures required to give maximum indicated thermal efficiency.

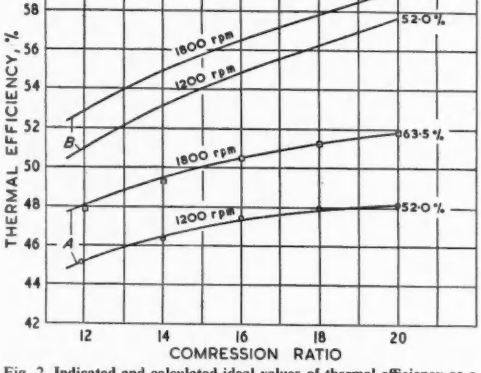

Fig. 2. **Indicated and calculated ideal values of thermal efficiency as a function of compression ratio at 1200 and 1800 rpm for different mixture strengths.**

The net result is that, as compression ratio is increased and the mixture strength required for maximum indicated thermal efficiency is decreased with an increase in speed, the percentage by which the indicated values fall below the ideal values decreases rapidly, as shown in Fig. 2.

Highest Usable Compression Ratio with Maximum-Power Mixture Strength

Approximately correct hydrogen/air mixtures were always required, and were usable at a compression ratio of 14 and at speeds of 1200, 1500, and 1800 rpm, as shown in Fig. 3. The highest value for indicated mean effective pressure was 143 psi, obtained at a speed of 1500 rpm, as shown in Fig. 4, in which the relevant performance data are plotted for mixture strengths ranging from 65% weak to 75% rich.

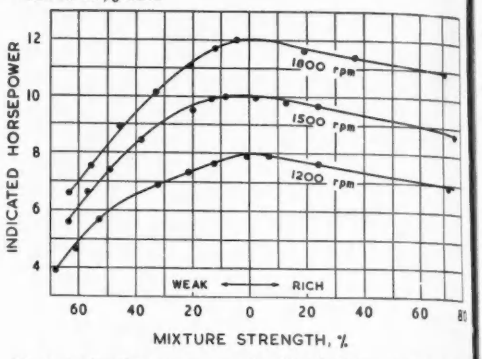

Fig. 3. **Indicated horsepower as a function of mixture strength with a compression ratio of 14 and at different engine speeds.**

With the compression ratio raised to 16, pre-ignition became evident when a correct mixture was used at a speed of 1000 rpm. The mixture-strength range in which operation of the engine was rendered impossible by pre-ignition increased with increasing speed, as shown in Fig. 5. Thus, for example, at 1500 rpm, operation of the engine was not possible over a range of mixture strengths extending from 25% weak to 55% rich.

Flame Velocity and Combustion Knock

It was significant that severe knock occurred under operating conditions in which there was neither pre-ignition nor detonation and that it persisted into extremely rich mixtures. When, however, methane, or natural gas with 95% methane, was used as the engine fuel without changing operating conditions, there was no occurrence of knock, pre-ignition, or detonation. Maximum power was then obtained with a mixture 10% rich. Regularity of spark ignition was obtained with mixtures ranging only from 35% weak to 40% rich.

Hydrogen and methane differ widely in respect of flame velocity after spark ignition. Thus, according to experiments carried out by Smith[2] at normal temperature and pressure, flame velocity in a correct hydrogen/air mixture was 170 cm/sec, and 40 cm/sec in a correct methane/air mixture. Flame velocity in the hydrogen/air mixture increased with an increasing concentration of hydrogen and attained a maximum value of 250 cm/sec when the mixture was 80% rich. In methane/air mixtures, flame velocity decreased with increasing methane content from its maximum value of 40 cm/sec for a correct mixture, until it was near the upper limits of inflammability with a mixture 80% rich, when flame velocity was only 8 cm/sec.

The difference in flame velocities between hydrogen and methane in mixtures with air appeared to afford an explanation for the differences between the fuels in respect of combustion knock in the engine, and it was therefore considered of interest to determine by means of indicator diagrams the rate of pressure rise and the flame velocity under conditions in which knock occurred in the engine in the absence of pre-ignition or detonation.

A capacitance type of pressure pick-up with a flush diaphragm and rated for a maximum pressure of 5000 psi, the associated electronic equipment, and one beam of a dual-beam oscilloscope were used to obtain the

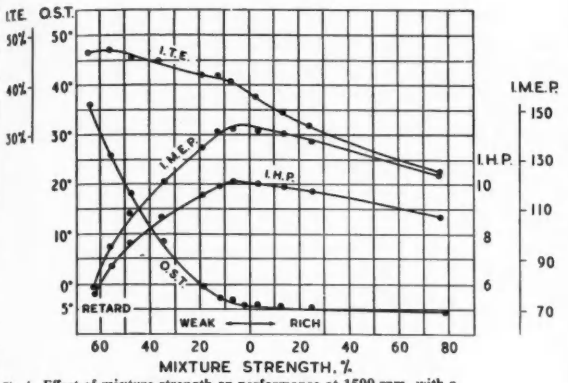

Fig. 4. Effect of mixture strength on performance at 1500 rpm, with a compression ratio of 14.

pressure-time diagrams. The other beam was used to register timing blips fed into the electronic circuit at top dead centre and at intervals of 10 deg. of crank revolution for 30 deg. before and after top dead centre. Blips were also fed into the circuit at 60 deg. before and after top dead centre. The times of passage of the spark were indicated similarly and more clearly by short vertical lines drawn on the diagrams, top dead centre being indicated by long vertical lines. The spark plug was fitted into the cylinder wall, with the points not quite flush with the wall. The length of flame travel after ignition was, however, taken as $3\frac{1}{4}$ in., the diameter of the cylinder. One degree of crank revolution requires a time of $1{\cdot}11 \times 10^{-4}$ sec at a speed of 1500 rpm, and the pressure-time diagrams obtained for compression ratios of 12 and 14 showed that combustion-pressure rise began in 1·5 deg. or $1{\cdot}6 \times 10^{-4}$ sec after passage of the spark, followed immediately by small pressure waves which persisted into the expansion stroke. The shape of the diagrams indicated that combustion had been virtually complete when combustion pressure reached its maximum value. Flame-velocity values, computed from these indicator diagrams, were 4830 cm/sec for a compression ratio of 12, and 5160 cm/sec for a compression ratio of 14. The corresponding calculated values for compression pressure and temperature, based on an initial temperature of 120°F and a value of 1·38 for the ratio of the specific heats, were 437 psi and 1035°F for a compression ratio of 12, and 556 psi and 1120°F for a ratio of 14, the respective burning times being $1{\cdot}74 \times 10^{-3}$ sec and $1{\cdot}60 \times 10^{-3}$ sec.

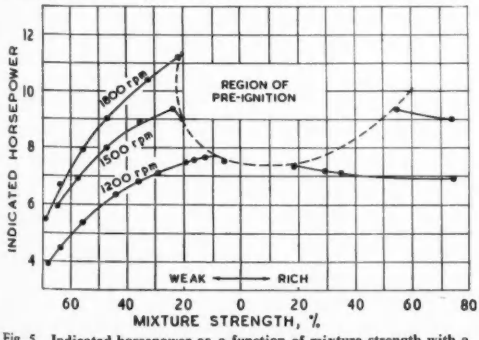

Fig. 5. Indicated horsepower as a function of mixture strength with a compression ratio of 16 and at different speeds, showing region of pre-ignition.

The above flame velocities of 4830 and 5160 cm/sec are based on data obtained from single cycles and, although successive cycles do not repeat exactly, they are consistent with the related values of compression ratio. They are 28 and 30 times respectively greater than the laminar flame velocities in a correct hydrogen/air mixture at atmospheric temperature and pressure, as measured by Smith[2], but are extremely small compared with the velocity of the detonation wave of approximately 2800 m/sec that can be generated after spark ignition of a correct hydrogen/oxygen mixture in a long closed tube. Laffitte[3], with a glass tube, 100 cm long, at a temperature of 15°C and with a correct hydrogen/oxygen mixture, found that, after spark ignition at one end, a flame run of 60 cm occurred prior to the setting up of a detonation wave. The required length of run increased as temperature was increased until, at 300 to 320°C, detonation did not occur. The length of flame run in the C.F.R. engine was 8·25 cm only, and the generation of a detonation wave after spark ignition of a hydrogen/air mixture dependent on a preliminary length of flame run would not be possible.

Conclusions

The experimental results obtained by means of indicator diagrams show that, when hydrogen is used as the fuel for an Otto-cycle engine, combustion knock can occur in the absence of pre-ignition or detonation, because of the high rate of burning of mixtures with air. Then, if the combustion of successive layers of mixture is completed in the flame front as it passes through the mixture, the rate of burning can be taken as the velocity of flame propagation. This in turn is dependent on the temperature coefficient of the oxidation reaction. Tizard[4], as the result of experiments with hydrogen as the fuel for a Ricardo E 35 single-cylinder engine with variable compression ratio attributed combustion knock to the relatively high value of the temperature coefficient. He was in error only in describing knock as detonation in accordance with commonly accepted theory.

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(2) F. A. Smith: *Chem. Rev.*, Vol. 21, 1937.

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Silver-Plated Aluminium Bus-Bars

(*Concluded from page 149*)

istics of the product have been found to be excellent and to meet all known standards, while the degree of formability is the maximum consistent with good corrosion resistance. Thus, rectangular bus-bars up to $\frac{1}{2}$ in. in thickness can be bent flat through a $\frac{1}{2}$-in. radius, with no flaking of the plating and with minor cracking, while satisfactory resistance to corrosion can be expected for all but severe conditions. Joints can be made by bolting and welding, and copper and aluminium wire may be soldered or brazed to the plated bus-bar with no special surface preparation. The thickness of silver is consistent with good abrasion resistance and low joint resistance.

U.S.A.

Some Aspects of Explosive-Forming Techniques

By J. S. RINEHART, V. PHILIPCHUK, and J. PEARSON. (From *Steel*, Vol. 144, No. 3, January 19, 1959, pp. 62-65, 1 illustration)

It is known that explosive-forming can produce a number of remarkable effects, but the reasons for some of these effects are not known. This article combines the views of three authorities on what is known about the forces at work during the explosive-forming of metals.

EXPLOSIVE-FORMING is a comparatively new process, and at the moment it is perhaps difficult to assess its real value. It is true, however, that explosive-forming can be used to shape metals which cannot be handled in any other way, that it eliminates spring-back when forming even the toughest metals, that it hardens aluminium by as much as 95% without altering its size, and that it increases the elongation of a carbon steel to 70%, as compared with the normal limit of 42%.

As Rinehart points out, in seeking for the reason for such effects, technical experience is at present meagre, and much more fundamental investigation is required to understand the dynamics of the explosive-forming process in all its stages. The facts are that the explosives generate a short-lived pulse of extremely high pressure, e.g., 4×10^6 psi. If the explosive is in intimate contact with the metal, exceedingly high stresses are generated just inside the metal, setting up a transient stress disturbance which passes through the metal, producing fractures, plastic flow, and other deformations. Such situations have been extensively explained, and the fundamentals are well understood. It is, however, a vastly different proposition when the explosive is located at a distance from the metal. If the space is air, peak pressure will be greatly reduced. Liquids are much better; for example, water helps to round off the pressure pulse, and, while it reduces peak pressure, it prolongs the action.

An abrupt pressure rise followed by a rapid decline causes fracturing (contact explosions). In short, a gradual pressure rise and decay are preferable. Pressures in an explosive/water/metal system are relatively low (a maximum of a few hundred thousand pounds per square inch), and their duration is in thousandths of a second, compared with the millionths of a second in the case of closely coupled metal/explosive systems. In conventional forming methods, stress distribution is exceedingly complex, and there are many opportunities for high stress concentrations. An explosion in a liquid distributes itself more uniformly, penetrating evenly into every crack, crevice, and corner, and may be compared to a well-lubricated die, continuously and instantaneously conforming to the metal during forming.

As a rule, metals are less ductile when deformed rapidly. A few metals (notably the high-manganese and high-nickel steels and certain aluminium alloys) show equal ductility at high and low strain rates. Copper and certain nickel-steel alloys become more ductile when stretched rapidly. Few tests have been run to determine the effect of strain rate on ductility. Fortunately, it is possible to draw many analogies between low temperatures and high rates of strain.

None of the present applications turns the metal to a fluid. Metal will seem to be much stronger (sometimes 70%) at high rates, because plastic flow is inhibited. Critical impact velocity is quite an important factor and may be considered as the ability of a metal to hold together when different velocities in various places work against each other. Mild annealed steel has the lowest critical impact velocity. The steel with the highest critical impact velocity is the easiest to form.

As pointed out by Philipchuk, stretching or drawing metal involves rapid movement through the elastic into the plastic range, producing a permanent set within millionths of a second. Under high-rate stress-strain, plasticity differs from that of conventional conditions. As no one knows completely how metal acts under high stress-strain rates, it is only possible to theorize.

The atoms in a crystal are spaced and held by cohesive and repulsive forces. These forces are disturbed and rearranged under a stress which produces strain. The deformation of slip takes place among many planes in the crystal grain, total deformation being the sum of innumerable small displacements along innumerable slip planes. Slip interference, or braking, takes place when a grain boundary is encountered. Adjustments of the atoms, or healing, then take place through the cohesive forces between the atoms.

It is reasonable to suppose that, under high stress-strain rates, atoms go through a series of slipping, braking, and healing events quite rapidly. Ultimate failure occurs when the healing or cohesive forces between the atoms of the metal are insufficient to cope with continued slipping, i.e., when it is stressed too long. Consequently, by controlling the duration, it is possible to prevent failure and to locate a band of high stress-strain combinations suitable for forming.

The explosive method of forming differs from the mechanical method in that the highest stress is applied instantaneously. It has been found that the ability of a material to be formed explosively is a function of elongation, contributory factors being metal temperature, the explosive medium used, and some experimentally determined constant for each metal concerned.

Pearson points out that it is not really reasonable to expect only one basic explanation of why explosively formed metals behave as they do, inasmuch as, for one thing, explosive charges have the effect of forming, shaping, extruding, compacting, swaging, and welding. As a result, an explanation for one effect does not necessarily hold for the others, quite apart from the fact that, as already mentioned, different factors affect explosives in intimate contact with the work and those separated by an air gap.

Under high strain rates, the elastic limit, yield point, and ultimate and fracture strength all increase over conventional values. Loading rates of only 200 fps increase the ultimate strength about 50%, while the compressive yield strength of some steels can increase by 300%. When tensile loads are added to hydrostatic pressure, ductility becomes practically unlimited, and fracture strength is increased several hundred times.

One explanation for high resistance to fracture under such loads is that high pressure prevents the formation of flaws which would otherwise act as focal points for fractures. Under explosive pressures, parts of a workpiece move fast enough to introduce similar effects at high strain rates.

Two other points which govern behaviour are the pressure-time distribution and the way parts of a workpiece are moved. The pressure-time distribution is con-

siderably important and is controlled by charge size and shape, stand-off distance, and various buffer materials. In general, it may be said that the peak pressure should be reached rather quickly. For open-die, sheet-metal forming, transmitted pressure need be only in the lower range. Higher pressures are required when the explosive is in contact with the work. In open-die forming, a fairly long pulse is good, even though it may decrease peak pressure. In contact operations, too rapid a load release may have some bad effects. A material can take considerable elastic energy. The material, normally released while the load is decreasing, can over-extend during the recovery, and distort or fracture.

An explosive detonated near a part displaces the elements in two ways, i.e. (1) generated pressures push on the object, and (2) blast energy introduces particle motion (called a stress pulse). With an air gap between the metal and explosive, part motion is almost entirely by pushing. With a buffer or contact explosives, particle motion is more important. Velocities can range from a few feet per second for stand-off charges to several thousand for contact methods.

Stress-pulse magnitude and particle velocity can be accurately calculated; they can also be calculated for unusual cases where a sizeable shear wave is induced.

Many successful open-die, sheet-metal forming operations involve inert buffers which increase the load-release time (pulse duration). They also probably transmit energy into the workpiece, inducing particle motion.

To sum up, the following general conclusions can be made :—

(1) Under explosive pressures, metals are formed plastically. They do not become fluid, but move through the elastic into the plastic range, taking a permanent set in a few millionths of a second. The plastic state is different from that observed in conventional forming.

(2) An explosive force distributes itself far more evenly than the forces in a conventional forming die, producing even penetration into every crack and crevice.

(3) Under certain conditions, refractory metals are easier to form than comparatively ductile metals; such metals have greater ability to hold together when different velocities in various places are working against each other in an attempt to tear the metal apart.

(4) The hardness of metals formed explosively does not correlate with the hardness of conventionally formed metals, because different phenomena are being measured.

(5) It is possible that an explosion affects the atomic force relationship in re-arranging crystal slip planes, the atoms slipping, braking, and healing almost instantly.

RUSSIA

Brass-Surfacing of Ferrous Metals by the Flame-Fluxing Technique

By G. A. Asinovskaya, E. V. Belova, and H. M. Zelikovskaya. (From *Svarochnoye Proizvodstvo*, No. 2, February 1959, pp. 28-31, 6 illustrations)

The torch-brazing technique, which has been widely used in Russia for surfacing steel and cast-iron machine components, has considerable shortcomings. Owing to the high degree of volatility of zinc contained in the brazing alloys used, it is difficult to obtain metal deposits of sufficiently sound character and uniform grain structure. In addition, the temperatures generated during torch-brazing, being in many cases much higher than the melting point of the brass filler metal cause considerable intermixing of parent metal and brass, leading to the formation of cementite on the surface of cast iron or creating cracks on the surface of steel.

To overcome these difficulties, a flame-fluxing technique now being used in Russia employs a special gas-forming flux to improve the quality of the deposited metal layers and to prevent boiling out of the zinc from the filler metal. The flux used in this process is an easily combustible organic liquid, containing 66% to 75% methylborate and 34% to 25% methyl alcohol. The vapour of this azeotropic liquid is supplied to the acetylene line of an ordinary oxy-acetylene welding torch, where it burns in the flame. During this reaction, the vapour of the boric acid produced creates a fluxing material, while the methyl alcohol vapours contained in the flux are converted to carbon dioxide and steam.

To produce the vapour, a special generator is used (Fig. 1), comprising two tanks (1) and (2), the former for actual use, and the latter acting as a reserve. The reserve tank (2) is fitted with a lid (3), which houses a flux-regulating valve (4). The amount of both acetylene and flux vapour is regulated by means of a control lever (5). The acetylene passes through concentric wicks (6), impregnated with the liquid flux, picking up a regulated amount of flux vapour and delivering it to the flame at the torch tip. Because the flux has a strong tendency to hydro-

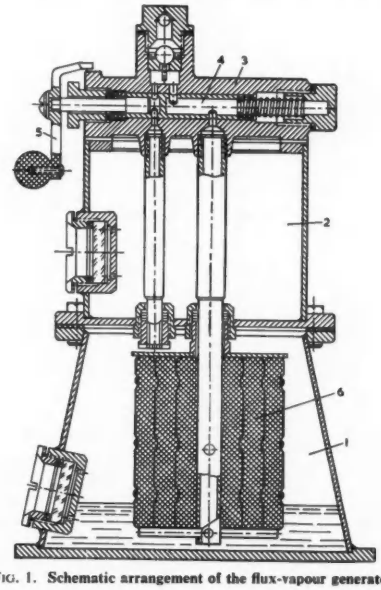


Fig. 1. **Schematic arrangement of the flux-vapour generator.**

lyse, a dryer is included in the line supplying the gas to the torch.

In the initial experiments with this flame-fluxing method, a silicon-bronze filler rod, known for its good brazing properties, was used. However, after examination of the brazed steel workpieces, it was found that, although evaporation of zinc from the brazing alloy was completely prevented, the bond between the deposited alloy and the parent metal was not sufficiently coherent, and in many cases, during further processing, the deposit broke away. Metallographic, X-ray, and chemical tests indicated that a distinct diffusion layer, 7 to 40 μ in thickness, was present between the parent metal and the deposited metal, and that this layer was responsible for the defects noted. This diffusion layer had an entirely different grain structure from that of the filler metal and showed a sharp increase in microhardness, compared with that of the parent metal and the deposited metal, as indicated in Fig. 2.

The results of chemical analysis showed that the diffusion layer was an alloy of iron and silicon, containing 80·4% Fe, 11·8% Si, 3·5% Cu, and 4·3% Zn. The X-ray examination showed a dissolution of silicon in alpha-iron. Altogether, it was evident from these investigations that the production of the diffusion layer took place not only by diffusion of iron into the bronze, but also by diffusion of silicon from the filler metal.

The same effects were found during brazing tests with cast-iron workpieces, the only difference being that the diffusion layer was not flat, as in the case of steel, but, owing to capillary forces, had an irregular surface, wedging into the cast iron and slightly increasing the adherence of the bond.

As a result of the partial failure of these experiments, tests were carried out with a new type of filler rod made of a brass free from silicon. This rod gave good results both with steel and cast-iron parent metals, producing highly coherent metal deposits of sound grain structure and uniform hardness. Analysis of these layers showed complete absence of polymorphous phases, establishing the complete dissolution of iron in the brass.

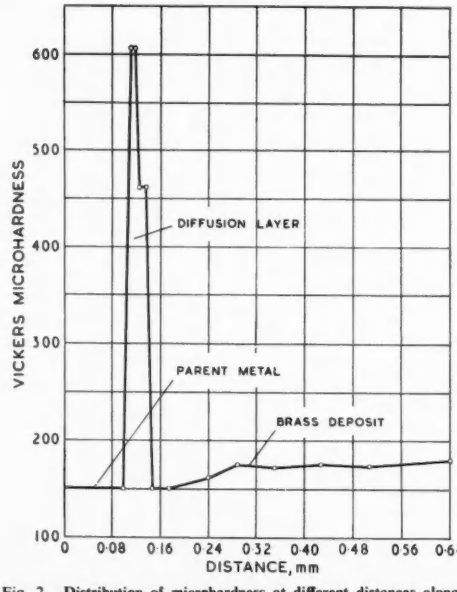


Fig. 2. **Distribution of microhardness at different distances along a section of parent metal, diffusion layer, and deposited brass.**

Great attention was paid during further tests to establish the optimum temperature ranges of the process. It was found that, although wetting of the working zone takes place at 600°C, at this temperature the melt quickly solidifies and does not leave enough time for the gases to escape from the deposit. At temperatures of about 900°C, good fusion was observed, but the high temperature of the filler metal leads to evaporation of zinc both in the case of steel and cast iron. The harmful effect of the very high temperatures in the case of cast iron is aggravated by the presence of graphite, which produces cavities in the parent metal.

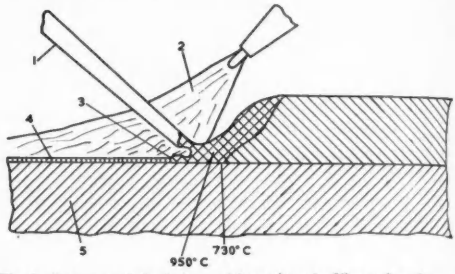


Fig. 3. **Recommended relative positions of torch, filler rod, and parent metal during flame-fluxing.**

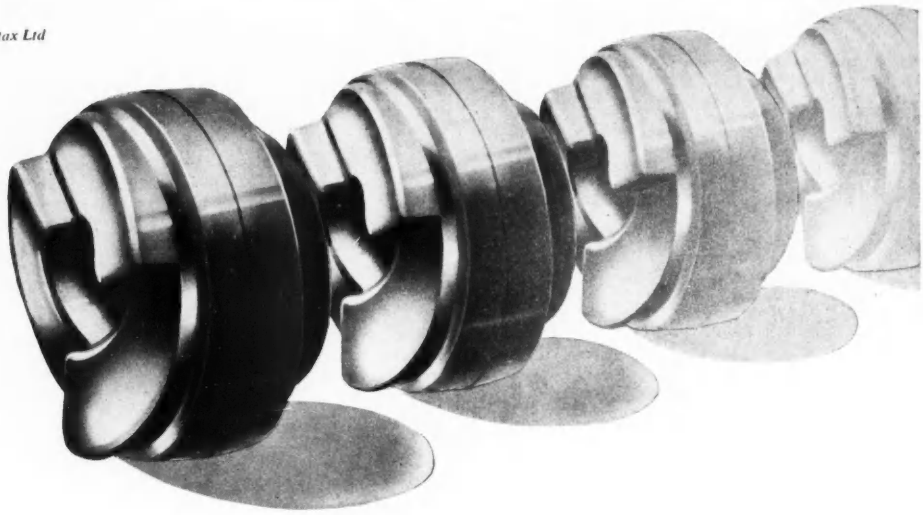
For both steel and cast iron, optimum results are obtained when the temperature is gradually raised from 700° to 850°C, but close control over the process is essential. The parent metal is initially heated to about 650°C, and the temperature is then slowly raised to between 700° and 850°C. If the process is carried out under the correct conditions, the flux imparts a characteristic uniform bright-green colour to the flame, As shown in Fig. 3, a thin transparent layer of flux (4) first appears on the surface of the parent metal (5), and the flame (2) then melts the tip of the filler rod (1), initiating metal deposition (3). The recommended angle between the torch and parent metal should be about 45 deg.

In addition, this flame-fluxing technique, using a brass filler rod free from silicon, was tried out on a production basis for surfacing the large steel discs of valves. A ring of brass was deposited on the periphery of the discs, and a thorough inspection of the finished components was then carried out. It was found that the deposited brass was free from non-metallic inclusions and pores, and there was no evaporation of zinc, while the average iron content of the brass layer was only 0·13% approximately. The Vickers microhardness of the layer was fairly uniform, its value ranging from 91 to 95. Tests showed that, as a result of surfacing, hermetic sealing of the valves was obtained under a working pressure of 16 atm, and that the brass deposit was able to withstand a stress of 36 kg/mm² without failure.

Similar results were obtained when cast-iron valve discs, 150 mm in diameter, were surfaced with brass in the same way. In this case, hermetic sealing was obtained under a working pressure of 25 atm, and failure occurred at a stress of 15 kg/mm², not, however, in the deposited layer, but much deeper in the parent metal itself.

As a result of the successful introduction of this surfacing technique into full-scale production, development of automatic flame-fluxing equipment on these lines is under way in Russia.

Courtesy of Rotax Ltd



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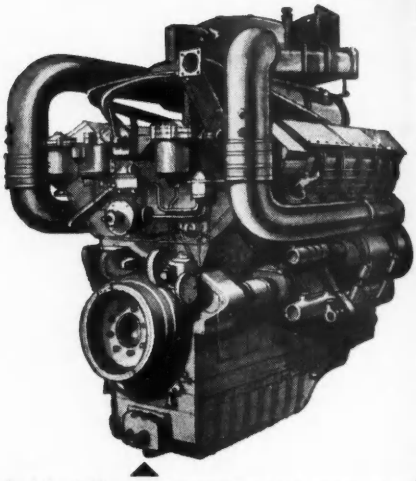
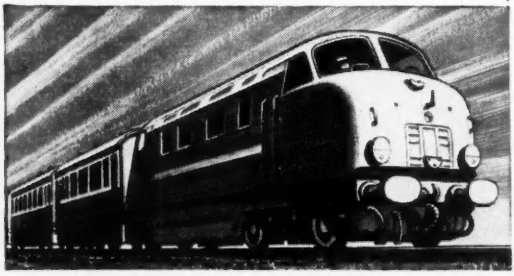


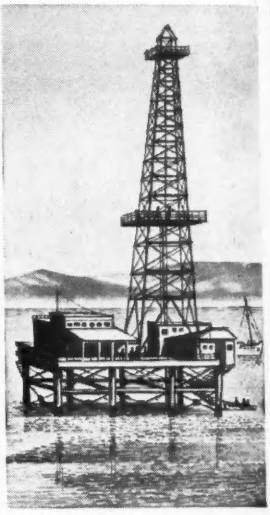
Typical of the MD range of engines is this Type 650 12-cylinder supercharged model with cylinders arranged in 'V' formation.

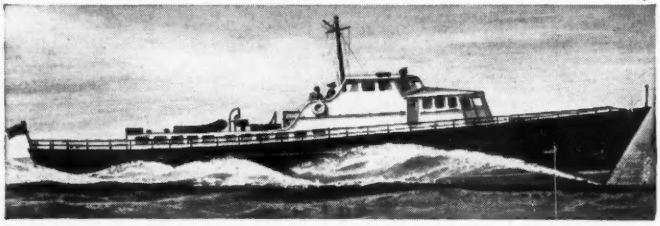


◀ Railway Traction 220-2,000 B.H.P.

Industrial Plant 220-1,750 B.H.P. ▶

Marine 220-3,000 B.H.P.





Armstrong Siddeley have the exclusive manufacturing and selling licence in the United Kingdom for the world-famous Maybach MD range of In-line and 'V' form diesel engines. These diesels range from 4-cylinder engines of 220 hp to 16-cylinder engines of 3,000 hp. They have an outstanding record of performance and reliability over millions of miles on railways throughout the world, and are widely used for marine propulsion and industrial power generation of all kinds.

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ENGINEERING, MARINE, WELDING, AND NUCLEAR ENERGY EXHIBITION

Covering well over 250,000 sq ft of floor space, the Engineering, Marine, Welding, and Nuclear Energy Exhibition, to be held at Olympia, London, between April 16 and 30, 1959, is the largest of its kind in the world and covers the latest equipment of more than 500 leading manufacturers in the fields of general engineering, welding plant, and power generation. In the following pages, details of a small number of representative exhibits by various manufacturers are given.

Rolls-Royce Limited

The representative range of diesel engines exhibited by the Oil-Engine Division of Rolls-Royce Limited is intended entirely for marine applications and includes an unsupercharged 4-cylinder engine developing 113 bhp at 1800 rpm, and a supercharged 6-cylinder engine developing 210 bhp at 1800 rpm without a charge cooler, or 230 bhp at 1800 rpm with a charge cooler. In addition, three applications of their C8.TFLM engines are featured, comprising an example of this turbocharged 8-cylinder marine engine, which develops 350 bhp at 1800 rpm, a similar engine developing 246 bhp at 1200 rpm, fitted in a Petbow 150-kW uncowled marine auxiliary generating set, and two of these engines coupled to drive a single output shaft through a Thornycroft gearbox. This interesting unit develops 670 bhp at 1800 rpm. These coupled power units have the advantage that they save a considerable amount of space and cost less than two separate units, are cheaper to install, and can be removed, overhauled, and re-installed far more quickly. One engine only can be used when power requirements do not warrant the use of both engines, the second engine being readily started when additional power is needed.

All these marine engines are supplied complete with their own coolant circulating pumps and fuel lift pumps. They are available with engine-mounted bilge pumps, generators, and air compressors, front-end power take-offs for winches, etc., and with power take-offs for auxiliary generator equipment, to suit individual requirements. If desired, they can be fitted with hydraulic or compressed-air starters, instead of the standard electric starter motor.

D. Napier & Son Limited

Among a wide range of exhibits, including turbo-blowers, castings produced by the "Napiercast" method of investment casting, specimens of titanium welding, and an example of a "Spraymat" heated panel, D. Napier & Son Limited are showing for the first time a turbocharged "Deltic" engine. This particular engine, the "Deltic" 18, is one of a number now being built for installation in the "Nasty" class of fast patrol boats ordered by the Royal Norwegian Navy.

This engine (Fig. 1) has a maximum output (15-min limit) of 3100 bhp at a crankshaft speed of 2100 rpm, and a continuous rating of 2400 bhp at 1800 rpm. At continuous power, fuel consumption is 0·417 lb/bhp-hr, while oil consumption is 9 pints/hr. The net dry weight of the engine, complete with gearbox, mounting feet, exhaust manifolds, piping, turbocharger, air starting valve, and distribution piping, is 12,700 lb. The overall length is 155 in.

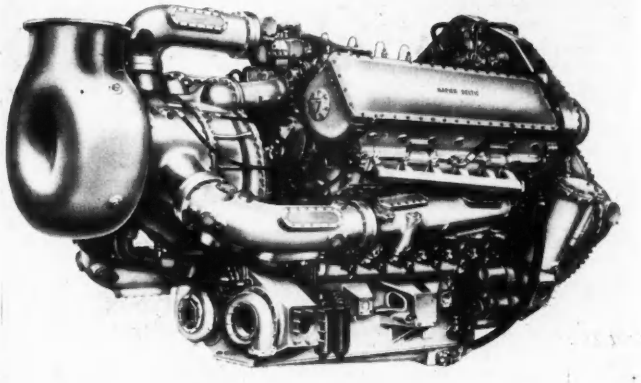

Fig. 1.

The English Electric Company Limited

The main exhibit of The English Electric Company Limited is part of a comprehensive a.c. auxiliary installation under supply for five B-class motor cargo-liners under construction for the British India Steam Navigation Company Limited by Harland & Wolff. This installation comprises:—

(a) A 6SRK exhaust turbocharged diesel engine directly coupled to a 350-kW, 440-V, three-phase, 60-cps alternator, both mounted on a combination under-bed. Four such sets will be installed in each vessel.

(b) A main a.c. distribution switchboard, consisting of OB2-type air-break switchgear for controlling the supply from four 350-kW diesel alternator sets, and comprising 4 alternator control/exciter panels, 10 feeder panels, 1 synchronizing panel, and 1 alarm panel. This equipment is complete with the usual complement of alternator and feeder protective devices, including overload, short-circuit, and reverse power protection. A system of preferential tripping has also been incorporated and is arranged to cut out certain non-essential services in the event of a sustained overload.

(c) A "Superform" marine sub-switchboard, one of nine such boards

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"10,000 HOURS — NO REPAIRS"
"The engine has been running a Mortar Mill 40 hours a week for five years; during that time there were never any repairs done, in fact the head was never off."
John McMillan & Son, Whitehouse, N. Ireland.

The skill and experience associated with the production of the world-famous Armstrong Siddeley Aero Engines lies also behind the design of the Armstrong Siddeley diesel.

The manufacture of this range of air-cooled units has now passed to the Staines factory of Petters Ltd., whose sixty-three years of engine manufacturing experience will ensure continuity of quality.

The extension of the well-known Petter service organisation to the Armstrong Siddeley range will maintain the usefulness of these units wherever they are in service and for whatever purpose they are being used.

Three models: 6-11 b.h.p., 14-22 b.h.p., 20-33 b.h.p.

Leaflets are available on request.

"AMAZED AT THEIR RELIABILITY"
"I have six of the 6-11 h.p. Armstrong Siddeley Air-Cooled engines; I must say I am more than satisfied with the engines and amazed at their reliability taking into account the very dusty air, sandstorms, and a temperature of around 123°F."
K. R. Gregory, Qatar, Persian Gulf.

"DONE A WONDERFUL JOB"
"The Armstrong Siddeley Air-Cooled engine has done a wonderful job; one set of rings and two valve grinds, and still uses no oil between changes."
V. Altman, Victoria, Australia.

ARMSTRONG SIDDELEY Air-Cooled Diesels

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CPH/AS9/1

being supplied for each vessel and being the marine version of the well-known English Electric "Superform" range. It is flush-fronted and fully insulated throughout, so that live metal cannot be touched inside the switchboard. The circuits are switched by chassis-mounted fuse switch units controlled from the front by retractable operating handles. Unit construction is employed, enabling a compact switchboard to be built up from switches of all ratings.

(d) Three "Red Spot" fuse distribution boards, showing recent design features, particularly for the safety of operating personnel.

(e) A complete range of T-type cartridge fuse links approved by Lloyds Register of Shipping.

Other exhibits by English Electric include a working model of a 16CSV exhaust turbocharged diesel engine with charge cooling and directly coupled to a salient-pole type of alternator. This is a model of the largest diesel-alternator set manufactured by the company at present, and has an output of 2504 bhp, 1780 kW. In addition, an 8VD dual-fuel engine drilling rig, similar to the five recently commissioned by the Iraq Petroleum Company Ltd. for deep-well drilling, is being shown. This set is coupled to a hydraulic coupling, the output at the coupling being 627 bhp for continuous operation, or 683 bhp for intermittent operation.

Bristol-Siddeley Engines Limited

In addition to a sectioned Bristol Siddeley "Proteus" gas-turbine marine engine with a continuous rating of 2800 shp, and a quarter-scale model of a 3-MW turbo-generator, comprising a simple lightweight gas turbine without a heat exchanger and incorporating a "free-power" turbine coupled to a 3·2-MVA alternator, Bristol Siddeley is exhibiting a selection of 6-, 12-, and 16-cylinder Maybach MD-type diesel engines. These high-speed lightweight engines are now manufactured in the U.K. by Bristol Siddeley under licence from Maybach Motorenbau G.m.b.H., and are characterized by a number of features specially designed to reduce wear and increase reliability. Also, since all models have the same cylinder bore and stroke, as well as many identical components, interchangeability of parts is readily achieved.

Bristol Siddeley Maybach MD-type tunnel engines are single-acting four-stroke units, with from 4 to 16 cylinders and constructed either as in-line or Vee models, naturally aspirated or pressure-charged, with a power range from 200 to 3000 hp. The MD 871/30 16-cylinder Vee engine, rated at 2880 hp at 1800 rpm, is shown in Fig. 2. The cylinders of all types of these engines are 185 mm × 200 mm, and outstanding design features include unit

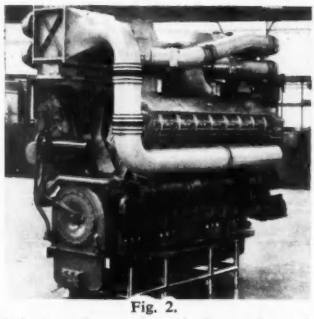


Fig. 2.

injectors for each cylinder, a forged one-piece crankshaft carried in a single-piece tunnel housing, pressure-oil-cooled pistons with detachable steel crowns, individual cylinder heads with a central combustion chamber, and small well-cooled valves with automatic clearance adjustment.

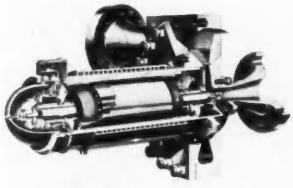


Fig. 3.

Other interesting Bristol Siddeley exhibits include models of gas-bearing machines, showing the major components of compressors and pumps under development. These units are designed to overcome the disadvantages of oil-lubricated bearings where support for rotating shafts is required in applications in which contamination due to leakage cannot be tolerated, and also in nuclear power plant where bearings, once installed, may be inaccessible. Since the supporting medium in these bearings is a film of gas, there is no metal-to-metal contact under operating conditions, and the load-carrying capacity increases with speed, temperature, and pressure. The rotating unit consists of an impeller attached to a shaft, at the other end of which is fixed the rotating member of the thrust-plate system. The shaft is driven by a squirrel-cage rotor-stator unit, and speed control can be achieved by the use of auxiliary frequency-changing equipment. In the case of a compressor, gas leaks down the back face of the impeller and fills the entire motor body with the gas being circulated. This gas forms the lubricant on which both the journals and thrust-plates run. In the case of

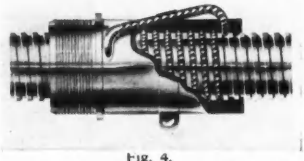


Fig. 4.

pumps, these are operated in the vertical position, and the liquid being pumped is contained in the bowl, above which is maintained a blanket of gas which provides the bearing lubricant and prevents oxidation of the fluid being pumped. In both cases, the motor body is designed as a pressure vessel suitable for pressures up to 1700 psi. An example of a Bristol Siddeley gas-bearing compressor is illustrated in Fig. 3.

Other exhibits from Bristol Siddeley include recirculating ball screws and splines, an example shown being a recirculating ball screw, 40 in. in length, with a pitch-circle diameter of 1½ in., produced for machine-tool applications. This ball screw is representative of a comprehensive range of high-precision units, manufactured by Bristol Siddeley in agreement with Beaver Precision Products of America. Ball screws have many applications in all spheres of the engineering and nuclear-engineering industries. Features include high efficiency, complete elimination of backlash, long life,

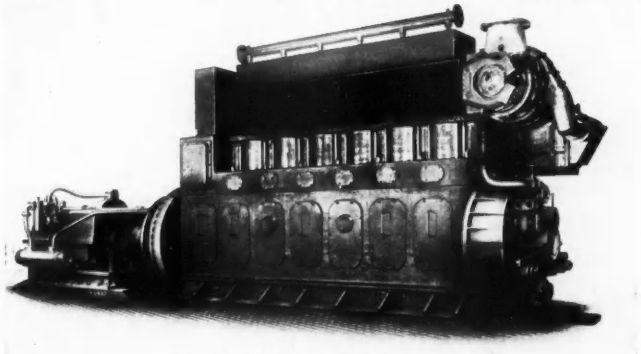
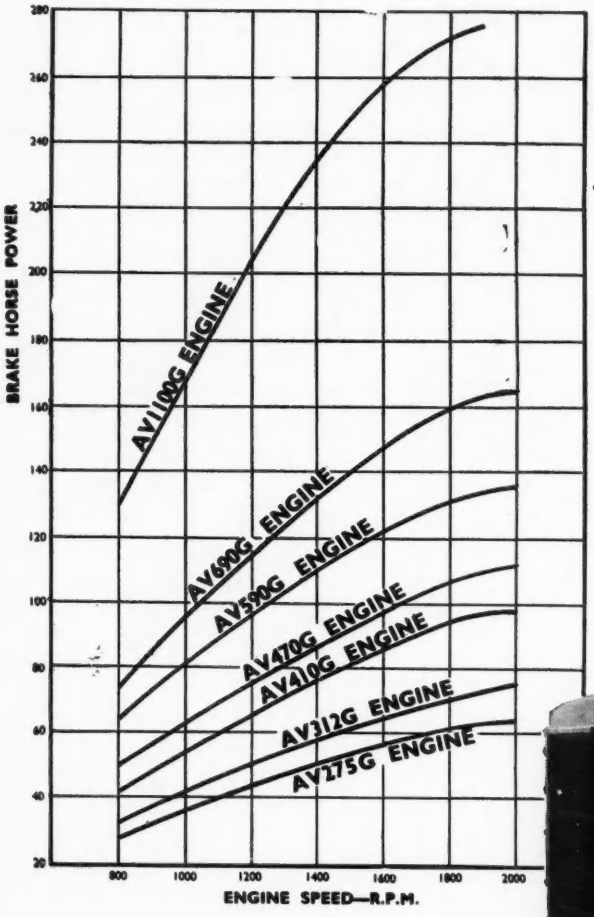


Fig. 5.



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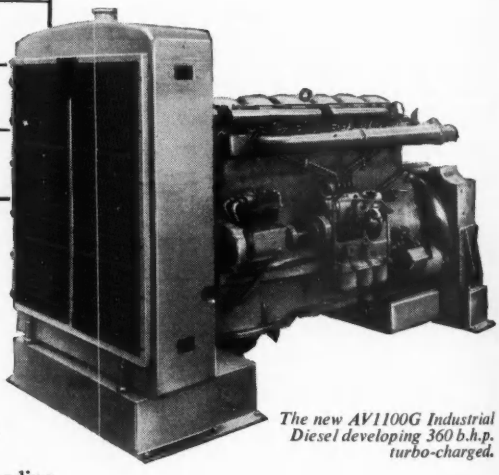

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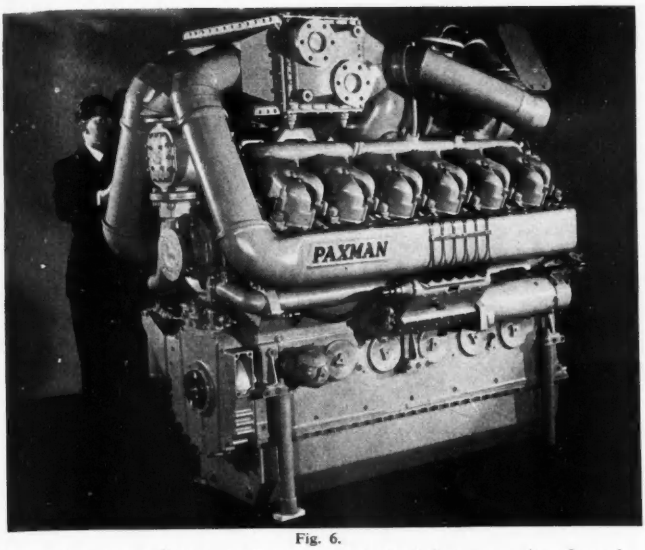

Fig. 6.

low maintenance factor, and up to 80% reduction in the power required for actuation, as compared with conventional screw threads and splines. Furthermore, they possess an inherent ability to run at high temperatures without lubrication. The method of actuation of a recirculating ball nut and leadscrew is shown in Fig. 4.

Ruston & Hornsby Ltd.
Davey, Paxman & Co. Ltd.

Several entirely new exhibits are being shown for the first time by Ruston & Hornsby Ltd. and their associates Davey, Paxman & Co. Ltd., and include two entirely new water-cooled power units of revolutionary design, i.e., the Ruston "6ATC" and the Paxman "Ventura". The 6ATC (Fig. 5) is a 6-cylinder, pressure-charged and intercooled engine and is the representative exhibit of Ruston's new "AT" medium-speed, pressure-charged diesel range, which covers 705 to 1685 bhp in five sizes, from five to nine cylinders. This engine from the ATC series is of particular interest, as it represents the first entirely new diesel engine in this power range to be introduced by Ruston over a period of about twenty years.

The Paxman "Ventura" is of equal importance, inasmuch it is a Vee-form diesel engine with a power weight ratio which is probably unmatched by any other water-cooled power unit in the 500 to 1870 bhp range covered by this new engine. The "Ventura" has been designed as an addition to the well-known RPH and YHX engines and for applications where low weight is of prime importance. Thus, as an indication of what has been achieved in its design, the 12-cylinder "Ventura" (Fig. 6), though of approximately the same bore and stroke, has a rating which is twice that of the 12RPH, but has a specific weight which is 60% less and occupies no more space.

Another extremely interesting exhibit is what is undoubtedly the largest air-cooled power unit in commercial production in the world. This engine is the "Vega" 12YGA (Fig. 7) and is from Paxman's new "Vega" range of Vee-form air-cooled diesels, which cover 200 to 466 bhp, and which now enables the Group to offer air-cooled power units ranging from 4 to 466 bhp.

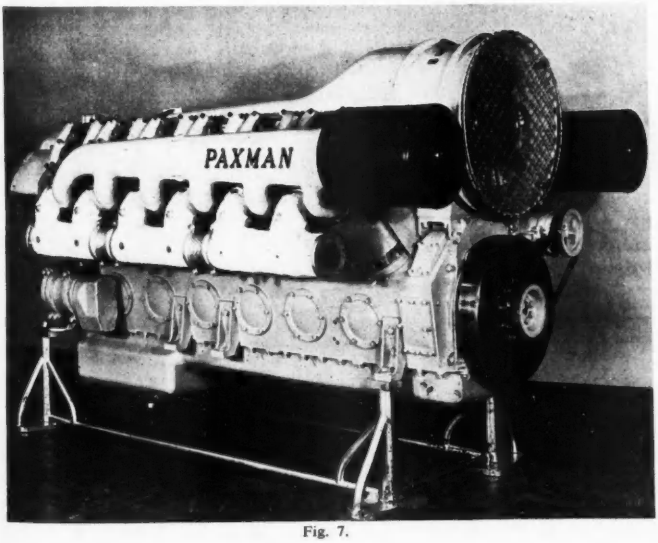

Fig. 7.

The National Gas and Oil Engine Co. Ltd.

The GS.34 free-piston gasifier, manufactured under Pescara/S.E.P./Muntz licence by The National Gas and Oil Engine Co. Ltd., generates the equivalent of 1000 hp, and up to ten gasifiers may feed gas to a single turbine, which may be coupled directly to the driven machine or through reduction gears. Two turbines can be connected to a single reduction gear, so that sets can be arranged for powers from 1000 to 20,000 hp. As the moving masses in the gasifier operating cycle are opposed and perfectly balanced, there is complete freedom from vibration, while the abolition of connecting-rods and crankshafts gives a unit of much lighter weight and smaller dimensions than a conventional diesel engine of the same output. A sectioned view of the National GS.34 free-piston gasifier is shown in Fig. 8.

Basically, the free-piston gasifier may be considered as a supercharged diesel engine, working on the two-stroke cycle, with opposed pistons. Its function is not to supply mechanical power itself, but to act as a generator of power gas, which is then used in a gas expansion turbine. Since the gasifiers and gas expansion turbine are not mechanically coupled, their position may be arranged to suit the requirements of any particular installation, and advantage can be taken of existing buildings. In arrangements employing several gasifiers, it is possible to shut down each gasifier unit individually for inspection or maintenance.

The 2000-hp unit on show consists of two National GS.34 gasifiers which, when operating, can supply

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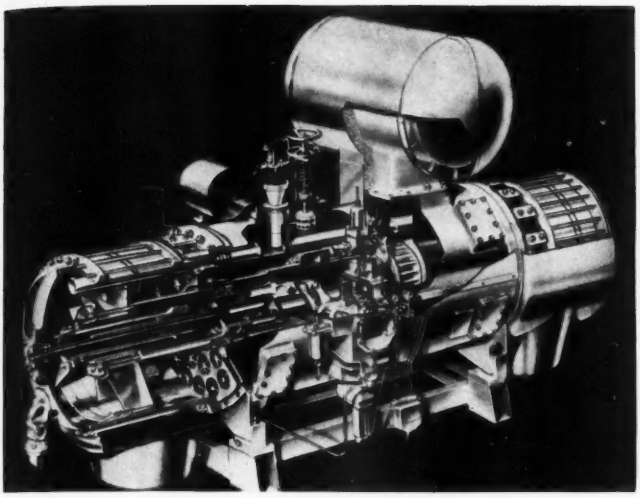


Fig. 8.

power gas at a temperature of 825°F and a pressure of 57·3 psia, and have a mass flow of gas of 17·6 lb/sec. The gas is supplied to a Hawker-Siddeley Brush 2000-hp axial-flow, five stage, gas expansion turbine, which runs at a speed of 9200 rpm. The exhaust gas from the turbine has an output temperature of 450°F and could be used in conjunction with a waste-heat boiler for the production of low-pressure steam for heating or other desired purposes. For industrial applications the plant will drive either an alternator, a pump, or a compressor through a suitable reduction gear. For marine propulsion, the unit drives through a reverse-reduction gear.

F. Perkins Ltd.

The new direct-injection Perkins Four 270D marine and industrial engines are being exhibited for the first time by F. Perkins Ltd. This engine, which is the first direct-injection unit to be put into production by the company, has the advantages of exceptionally low fuel consumption and easy starting in cold weather. The industrial version develops 56·5 bhp at 2000 rpm, and the marine version 58 bhp at 2000 rpm. The industrial version is suitable for many types of industrial equipment, and a wide range of flywheels, flywheel and clutch housings, and manifolds is available to increase versatility. It is also available in stage-by-stage form up to a complete power-pack, to suit individual requirements. The marine version can be fitted with a Parsons mechanically operated reverse gearbox supplied as a direct drive, or with 2 : 1 or 3 : 1 reduction gears. Oil-operated Parsons or self-change gearboxes can also be supplied. The combustion chambers of this engine are formed in the piston crowns, and fuel is injected directly into the chambers, which are toroidal bowls slightly offset from the centre-line of the pistons, through four-hole injectors offset in the cylinder head. The engine has a bore of 4·25 in. and a stroke of 4·75 in.

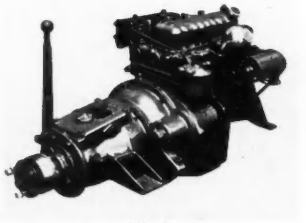


Fig. 9

Other Perkins exhibits include their new 6-, 16-, and 35-hp streamlined petrol outboard engines, which are water-cooled units with two-stroke power heads and develop maximum power at 4500 rpm, and their 1·6-litre Four 99 engine available for industrial and marine use. A Four 99 marine version (Fig. 9) is being shown with a Parsons D-type box, with a reverse gear for direct drive and arranged for direct sea-water cooling. This marine engine develops 35 shp at 3000 rpm for maximum continuous use, the intermittent rating being 40 shp at 3600 rpm. Basically, the engine is a four-cylinder in-line unit, with a bore of 3 in. and a stroke of 3·5 in.

Still other Perkins exhibits include examples of an industrial bearer-mounted Four 99 engine, complete with radiator, an S6(M) marine engine with gearbox, arranged for fresh-water cooling and developing 100 shp at 2000 rpm, and P3/144 industrial bearer- and pedestal-mounted engines.

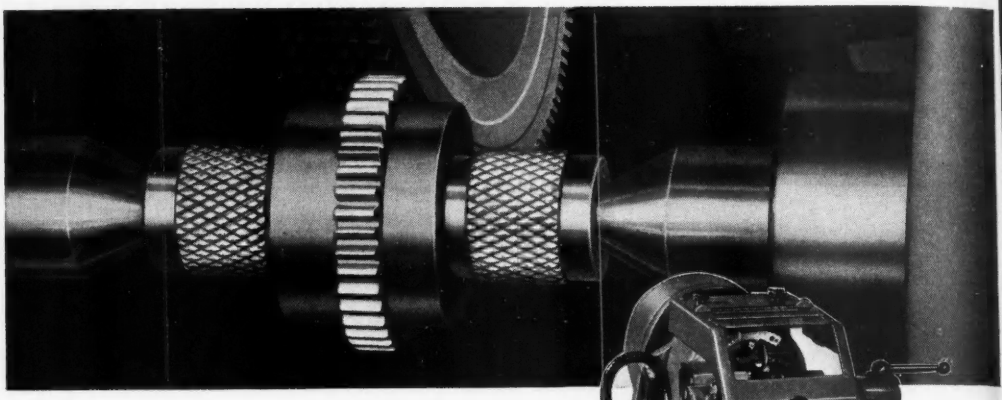
Metropolitan-Vickers Electrical Co. Ltd.

A prominent exhibit of Metropolitan-Vickers is the high-pressure cylinder casing and rotor for the 12,500/13,750-shp two-cylinder geared propulsion stream turbine for the new Eagle oil-tanker "San Conrado". The cylinder casing is in two halves, jointed at the horizontal centre-line, and is of cast steel. The rotor and wheels are machined from a monobloc forging. Two white-metalled journal bearings are employed, one being combined with a Michell thrust bearing. Turbine speed is 4840 rpm, and steam is admitted through stainless-steel nozzles at 585 psig and 840°F. There are eleven stages of blading, i.e., a velocity-compounded stage with stainless-steel fixed and moving blades, followed by ten single impulse stages having stainless-steel moving blades and built-up fixed-blade diaphragms with 0·5% molybdenum-steel blades assembled in centres and rims of the same material. The diaphragms are built up in halves and are retained in circumferential grooves machined in the top and bottom half casings. Steam conditions at the outlet and of the high-pressure cylinder are 35 psig and 383°F.

Another large Metropolitan-Vickers exhibit is a type HTAS 3000-hp, 3850-rpm filter-ventilated boiler-feed pump motor. This motor takes a low starting current, has a sufficiently high starting torque to accelerate quickly from rest to full speed, and has special features to ensure reliability, high efficiency, and quiet running, and to facilitate maintenance. A double inlet system of air circulation is used. A propeller-type fan is fitted at each end of the rotor core and, when the motor is running, cold air is drawn into the machine at both ends. This air is directed over the end-windings and through axial air ducts in the stator and over the periphery of the rotor core. It is then deflected through radial ducts in the stator core and finally discharged through a large aperture in the top of the yoke frame. This type of motor is supplied with a drip-proof enclosure (with or without air filter) or alternatively as a totally enclosed, closed-air-circuit machine with water-cooled air-coolers.

W. H. Allen Sons & Co. Ltd.

Representative of their wide range of power-generating plant, pumping machinery, and electrical equipment, exhibits by W. H. Allen Sons & Co. Ltd. include a Vee-form diesel-engine generator for marine duty, a rotor for a 1750-kW Allen marine-type pass-out turbo-generator, and three pumping units comprising prototype-model double-suction pumps designed for preliminary



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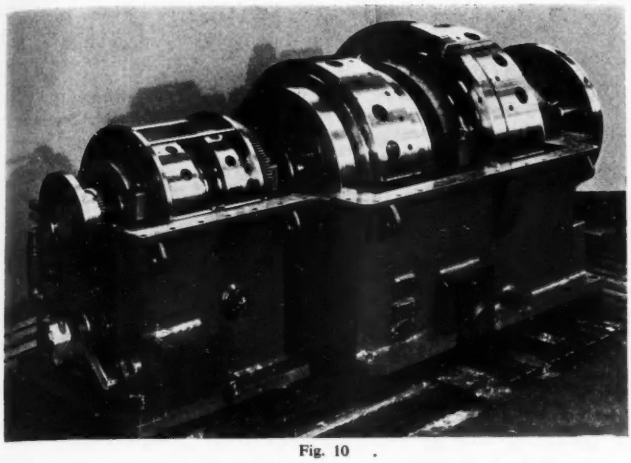

Fig. 10

testing purposes and intended for use in a waterworks, a sewage works, and a nuclear power station installation respectively. In addition, a large number of electrical exhibits is featured, including a 400-kW alternator for a diesel-engine drive, a 500-kW self-regulating alternator with excitation equipment, vertical and horizontal types of a.c. and d.c. motors, and a varied range of starters and other equipment for both marine and industrial applications. Also featured is an important development by the company, in the form of a scale-model of a shaft generator, designed for driving from the main engine of a ship for the supply of auxiliary power, the generator being built around the intermediate propeller-shaft.

Another interesting Allen exhibit is the Allen-Stoeckicht epicyclic gear shown in Fig. 10. This gear, intended for a 160-hp mine-tunnelling machine, is representative of the wide variety of applications for which Allen epicyclic gearing is used, and for which gear units are specially designed and built to meet individual requirements. This particular gear is a 160-hp two-speed unit for transmitting a maximum output torque of 110,000 lb-ft at a speed of 9 rpm. The gearbox is driven by a two-speed motor, providing an input speed of 1500 or 750 rpm, giving a range of four output speeds, i.e., 24, 18, 12, or 9 rpm. The two-speed gear is followed by a double-reduction gear. The gear unit has an overall ratio of just over 80:1, and this high reduction and large torque are obtained from a unit only 6 ft in length and weighing only 5½ tons. The largest annulus is 30 in. in diameter.

British Thomson-Houston Co. Ltd. A.E.I. Heavy Plant Division

A wide range of electrical and mechanical equipment for marine and industrial applications is being shown by The British Thomson-Houston Co. Ltd. and by the A.E.I. Heavy Plant Division. Thus, A.E.I. has a wide variety of heavy electrical plant, of which models of hydro-electric and rolling-mill equipment are representative, while BTH exhibits include a 450-kW, 440-V, 3-phase, 60-cps auxiliary geared turbo-alternator set, a permanent-magnet high-frequency single-phase generator, with an output at 2400 rpm of 1·5 kVA, 110 V, to meet Admiralty shipboard requirements, and a typical group starter board, class MMC, designed for the starting of auxiliaries up to 250 hp.

Other BTH exhibits include the prototype model of a simple magnetic-amplifier type of automatic voltage regulator built under an Admiralty development contract, and propeller tachometer equipment, developed by BTH in conjunction with Hardings (Leeds) Ltd., for indicating the direction and speed of a ship's propeller and counting the number of revolutions. A selsyn transmitter is coupled to the propeller-shaft and drives two selsyn receivers, one in the engine room and one on the ship's bridge. The engine-room receiver is used to drive a magnetic tachometer, a revolution counter, and a direction indicator. The bridge receiver drives a magnetic tachometer and a direction indicator and, for night viewing, the dial is provided with illumination controlled by a dimmer.

Another interesting exhibit is BTH vertical high-frequency generating equipment for induction-heating and smelting applications. This unit, which has an output of 75 kW, 8·7 kcs, comprises a heteropolar induction alternator and a squirrel-cage induction motor, the motor being mounted vertically above the alternator. The frame and the shaft are mounted on the bottom end-shield, and the set is supported on four resilient mountings. The set is totally enclosed inside sheet-metal coolers, which can be easily removed, and is cooled by two water-coolers, one being placed in the alternator stator core and the other wound spirally round the motor frame. Under suitable conditions, these high-frequency alternators may be operated in parallel to supply higher powers than can be generated by a single unit.

Leslie Hartridge Ltd.

An interesting exhibit by Leslie Hartridge Ltd. is a heavy-duty fuel-pump test bench, designed for testing the heavier diesel engines. The fuel, the supply of which is accurately controllable, can be delivered to the pump either by gravity or pressure up to 150 psi. The fuel pump is driven via an infinitely variable speed gear by a 5-hp constant-speed motor, and any desired speed can be obtained accurately from 0 to 750 rpm.

Other exhibits on the Hartridge stand include a nozzle-reconditioning machine suitable for servicing injectors having needle and body angles between 20 and 170 deg. The diesel-nozzle analyser, already manufactured for some time by the company, has now been fitted with a built-in fume exhauster and is provided with a wide range of adaptors. Accuracy of testing is achieved by controlling the length of the injection period, so that the action of the needle can be observed in slow motion.

Hydraulics and Pneumatics Ltd.

As is only to be expected, the wide range of exhibits by Hydraulics & Pneumatics Ltd., the sales subsidiary of the Turner Manufacturing Co. Ltd., emphasises hydraulic and pneumatic units, and includes a variety of hand pumps, air compressors, hydraulic tank units, a unique selector valve incorporating no-leak ball valves, automatic variable-delivery pumps, and a revolutionary actuator which it is believed has not so far been seen in industry in such a simple form.

The H.P. A.V.D.29 automatic variable-delivery pump (Fig. 11) enables pressures from 500 to 2500 psi to be set at any desired pressure by means of a simple hand control. When the pump reaches the preselected pressure, the pump automatically moves into a no-stroke position and no oil subsequently flows, except to replace any losses in the circuit itself. This means that the pump will maintain the selected pressure and replace any losses in the circuit with practically no power consumption, offering the very greatest economy in use. On account of the automatic feature of moving into no-stroke when pressure is reached, it is generally unnecessary

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The Ilford AZOFLEX Model 246 Combine printing and developing machine (formerly known as Model 46/35) is designed for use in the print room of the large drawing office. It does not produce unpleasant fumes and special ventilating systems are thus unnecessary, making it a simple matter to move the machine to a new position at any time.

ENGINEERING, MARINE, WELDING & NUCLEAR ENERGY EXHIBITION
APRIL 16th TO 30th STAND No. 5 BB, EMPIRE HALL

- Exposure, development and print delivery synchronized for simplicity of operation.
- All controls conveniently located for rapid, effortless adjustment.
- Pneumatic-assisted handling of originals and sensitised material to obviate fatigue.
- Complete design co-ordinated for exceptionally high potential output.
- Excellent mechanical layout giving silent, vibrationless running.
- Comprehensive maintenance service available at nominal cost.

Capacity: rolls and cut sheets up to 42 in. wide.
Printing speed: from 2 ft. to 30 ft. per minute.
Lamp: H.P.M.V. quartz, 3,000 watt.
Dimensions: height 58 in., width 72 in., depth (tray extended) 80 in. Weight: approx. 1,400 lb.

Subject to certain conditions, the majority of AZOFLEX photoprinting machines can be hired as an alternative to outright purchase.

ILFORD *Azoflex*

PHOTOPRINTING MACHINES & MATERIALS

Full details from
ILFORD LIMITED,
INDUSTRIAL SALES DEPT, AZ18U
ILFORD, ESSEX. TELEPHONE: ILFord 3000

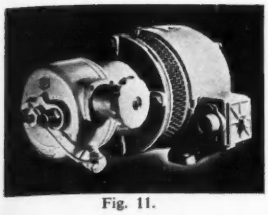


Fig. 11.

for large-capacity pumps to be used but, where a quantity of oil at low pressure is necessary, as in many press applications, there is offered a dual-pump or " Hi-Lo " pump unit. This comprises a 2½-hp double-spindle motor, having mounted at one end a low- or medium-pressure gear pump with the volume required but within the capabity of the motor, and at the other end the A.V.D. pump. This unit is capable of giving a high volume of oil output at low pressure, with automatic change-over to a low volume at 2500 psi.

Fig. 12.

The new H.P. hydraulic or pneumatic actuator drastically reduces the amount of piping normally required with conventional actuators, and incorporates a no-leak feature which ensures that the amount of oil required in the circuit is extremely small, with a consequent reduction in the size of pumps and accumulators. This actuator is available in two basic forms, i.e., as a non-servo actuator or as a servo-actuator. The non-servo version (Fig. 12, *top*) is a one-unit cylinder incorporating its control means within the cylinder, either for manual or for electrical operation. Installation is simple, in that only one pipe to the power supply and one to the exhaust are necessary. Control is by mechanical means, such as a cable or alternatively by a solenoid as part of the actuator. In the servo-version (Fig. 12, *bottom*), the valve is incorporated in the cylinder, with its operating means and also with positive locking. The valves can be so adjusted that extension of the piston rod to any reasonable limit can be achieved at the time of manufacture.

The General Electric Co. Ltd.

One of the outstanding features of the General Electric Company's exhibit is an alternator fitted with G.E.C. " Accurex " static excitation, designed to illustrate the advantages of quick response and voltage stability, as well as the mechanical merits of such equipment. The " Accurex " exhibit is arranged so that a number of motors can be started direct to line, with varying loads on the alternator, thus representing the type of conditions which might be encountered on board ship when the largest motors are started on a loaded system. The effect of these heavy power loads on fluorescent and other lighting systems is of paramount importance and the exhibit shows clearly, both on an oscilloscope and visually, the important advantages of this type of excitation.

Another G.E.C. exhibit shows a typical lighting scheme for the lounge of a passenger-cargo vessel, while other exhibits include Pirelli-General ship-wiring cables, G.E.C. smoke-detection equipment, and " Maxcess " fans manufactured by Woods of Colchester Ltd., an associate company of the G.E.C.

British LaBour Pump Co. Ltd.

In addition to an extremely wide range of vertical and horizontal self-priming pumps, the British LaBour Pump Co. Ltd., are exhibiting two new units, i.e., the type DSZ direct-mounted pump for chemical and general-purpose duties, and the type MSZ horizontal flooded-suction centrifugal single-stage process pump for hot liquids in the oil and petro-chemical industries.

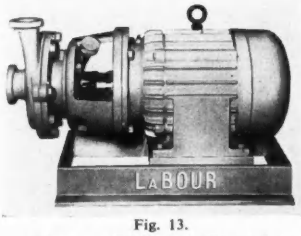


Fig. 13.

The type DSZ unit (Fig. 13) is a horizontal centrifugal single-stage pump, suitable for handling all types of liquors and slurries, and forms one unit with the drive motor, eliminating bearing brackets and simplifying construction. An exclusive feature is that suction and delivery pipes need not be disconnected when the pump is dismantled. The motor, pump back, and impeller are withdrawn in one unit, and can then be serviced and replaced, or a stand-by unit inserted. The impeller shaft is separable from the motor shaft and simplifies dismantling. When used on chemical duties, these pumps, which are produced in a range of capacities and heads up to 450 gpm and 250 ft, are available in a wide range of corrosion-resistant materials.

The type MSZ pump has been developed to handle hot liquids and incorporates water-cooled bearings, pedestals, and glands, adaptable water-harness, and spacer-type couplings. All wetted parts are available in cast steel, cast iron, stainless steel, and a wide range of corrosion-resistant alloys. The mechanical assembly is easily and quickly removed without disturbing pipe connections or motor, and without affecting alignment. These pumps are available in capacities up to 1000 gpm and heads up to 300 ft.

Goodyear Pumps Limited

A complete range of products featuring the positive-displacement rubber-to-metal Goodyear self-priming pump is being exhibited for the first time by Goodyear Pumps Limited, a member of the Holman Group. An important characteristic of this pump is that it is available in all sizes in Meehanite, bronze, and aluminium, while stainless-steel pumps will also be available shortly. Owing to its small size and the fact that only two moving parts are in contact with the liquid, construction in the more expensive metals offers a competitive range to suit most needs.

In addition to a range of fire pumps, air-motor-driven pumps, and a working exhibit of the new process pumping set, which produces 300 gph at 1440 rpm with a 150-ft head of water, including a 28-ft suction lift, the new Goodyear engine-room unit pressure set is being featured. This is a ready-built factory-produced pressure system, complete with pumps, motors, starters, pressure-switches, etc., for supplying from 2½ to 7½ tons of fresh and salt water to all parts of ships of any size. In this set (Fig. 14), the arrangement of piping is such that no weight of piping is loaded on the pumps and valves, all weight being supported by the framework. Included in the arrangement of valves for each system is a screw-down non-return valve to ensure that there is no leak back from the water in the tank when the pump is stationary.

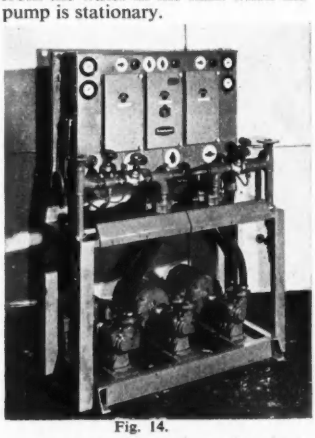


Fig. 14.

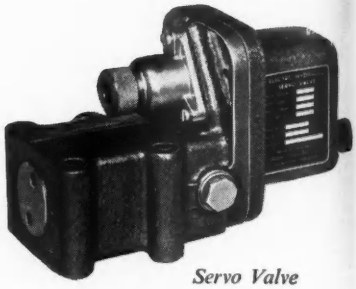
Another interesting Goodyear exhibit is their new mining pump set for face drainage, believed to be the first pump set of its type to offer such a high specific output, combined with high efficiency, low weight, and port-

THREE ESSENTIAL UNITS . . .

. . . for an electro-hydraulic servo system

1 SERVO VALVE . . .

. . . specially designed for industrial applications. Available for 2·5, 5, 10 and 15 g.p.m. From 4 watt input to 10 h.p. output. Suitable for operation up to 3,000 lb. per sq. in. in temperature range – 20°C. to + 100°C.



Servo Valve

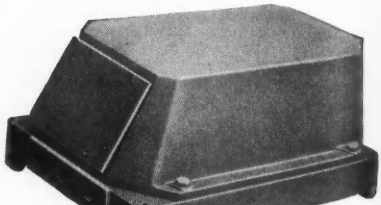
2 MICRON FILTER UNIT . . .

. . . for highly efficient filtration of particles greater than 5 microns from industrial hydraulic systems. Available for use assembled to the Sperry servo valve or separately as a line filter.

Servo Valve Filter

3 SERVO VALVE DRIVE AMPLIFIER . . .

. . . to provide the link between the signalling elements of the servo loop, e.g., Sperry inductive pick-offs, synchros or tachos, and the electro-hydraulic servo valve. Transistorised design, suitable for operation on 50 c.p.s. supply. *Max. output* — 600 mA. differential. *Gain* — 30 amp. per volt. Input resistance of 7 KΩ, output circuit 20—0—20Ω, i.e., *Power Gain* of 80 dB. Designed to comply with *industrial* conditions.



Servo Valve Drive Amplifier

Write, call or telephone for more detailed information

SPERRY

Technical advice and the loan of units for evaluation are offered in cases of specific interest.

SPERRY GYROSCOPE COMPANY LIMITED INDUSTRIAL DIVISION

Great West Road, Brentford, Middlesex. Telephone: ISLeworth 1241, Telex: 23800

ENGINEERING, MARINE, WELDING & NUCLEAR ENERGY EXHIBITION **APRIL 16th to 30th STAND No. 9 ROW F GRAND HALL**

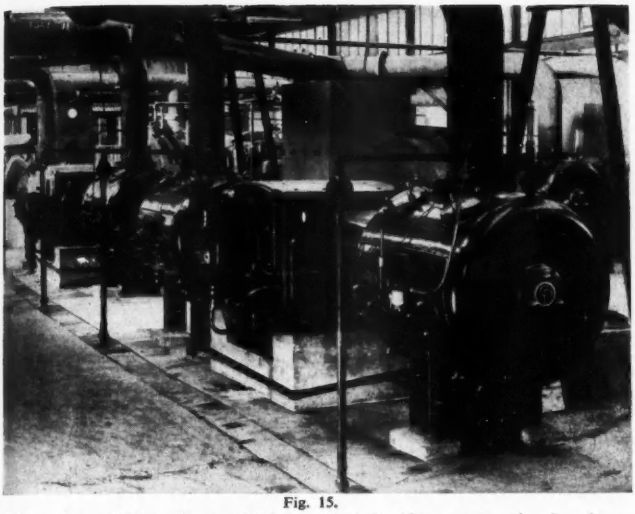


Fig. 15.

ability. In addition, it should be noted that the set has been designed to cope with many face-drainage problems where abrasive and often corrosive water has to be speedily and effectively removed from operating areas in the mine. The unit, which weighs about 625 lb, comprises a Goodyear positive-displacement pump, direct-coupled to a 1440-rpm, totally enclosed, fan-cooled flameproof electric motor. The pump delivers a constant 75 gpm of water at this speed, with a head of up to 200 ft and a suction lift up to 28 ft.

Stein Atkinson Vickers Hydraulics Ltd.

A representative selection of their British-made Vickers-Detroit oil hydraulic pumps, motors, control valves, actuating cylinders, power-assisted steering boosters for ease of rudder control in a heavy seaway, and complete power units is being exhibited by Stein Atkinson Vickers Hydraulics Ltd.

Special interest attaches to their new range of high-performance vane-type pumps for 2000-psi and 2000-rpm duty, and also to a new temperature- and pressure-compensated flow control for the speed control of actuating cylinders, regardless of changes in work loads and oil viscosity.

Consolidated Pneumatic Tool Co. Ltd.

Out of a wide range of equipment, including more than 100 different types of industrial power tools and a full range of "Hicycle" high-frequency electric tools, a very interesting—and certainly the largest—exhibit of the Consolidated Pneumatic Tool Co. Ltd. is one of their class FE range of compressors. The design of these horizontal, double-acting balanced opposed compressors lends itself to construction in a large number of sizes suitable for a very wide range of applications. Thus, by varying the sizes of cylinders or by increasing the number of crank-throws, units can be supplied for such widely varying needs as the supply of compressed air at 40 psi or for various industrial processes requiring up to 3000 psi, whilst capacities of up to 5000 cfm are obtainable. A particular feature of the design is the complete absence of vibration, as a result of careful selection of crank-angles, this being an important consideration in the installation of compressors which must be operated close to other plant. Fig. 15 shows the single-stage two-cylinder type FE.21 version, with a capacity of 2320 cfm at 40 psi.

Other Consolidated exhibits include the "Tornado" medium-weight rock drill for tunnelling, introduced last year, and some new additions to their lightweight range of pneumatic tools, including small $\frac{3}{16}$- and $\frac{1}{4}$-in. drills with 45- and 90-deg. heads, and a new lightweight sander on which flexible pads can be fitted for sanding curved surfaces. A special model, fitted with a water feed for dust suppression, is also being exhibited.

Broom & Wade Limited

In addition to a wide variety of pneumatic tools, Broom & Wade Limited are exhibiting a range of stationary compressors, including their new two-stage double-acting unit, type L2000, which delivers 2200 cfm of free air at 100 psi.

In this unit (Fig. 16), which operates at a speed of 375 rpm and is direct-coupled to a 415-hp motor, the aspired air flows freely through a new aerodynamic valve which permits a constant, unrestricted airflow speed to be maintained. From this point, the air again flows unrestricted, without reversal of direction, by way of cylinder-wall ducts specially designed to stimulate ram effect for good pumping efficiency. Through low-lift valves, the air passes from the low-pressure cylinder into an intercooler of advanced design, fitted with a compact and easily detachable heat-exchange element. The valves are of the automatic, low-lift, multi-plate type and are large enough to allow for low air velocity, while a 90-deg. arrangement has been adopted for the cylinders, ensuring excellent running balance, combined with lowest torque peaks. Furthermore, to ensure complete balance of reciprocating parts, the low-pressure piston is of aluminium alloy and is

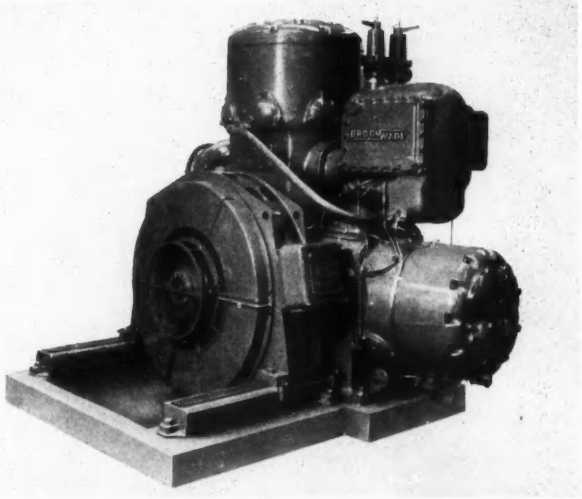
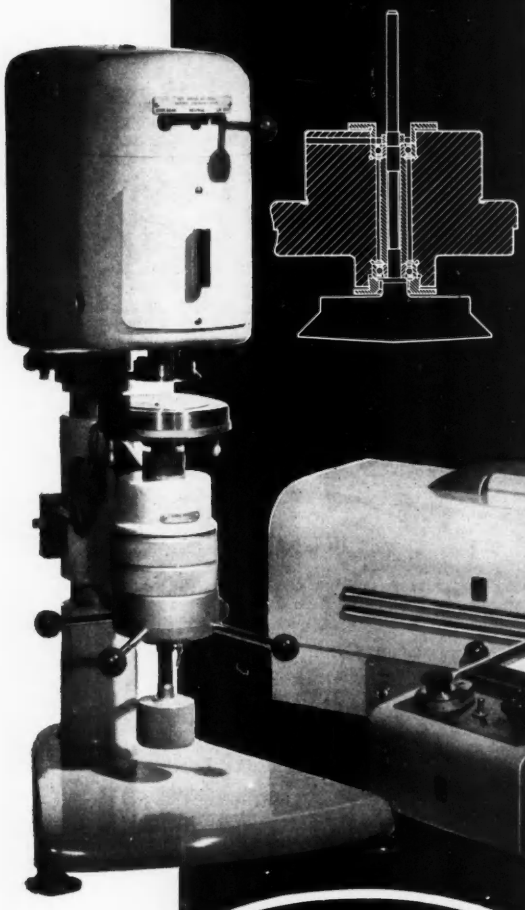


Fig. 16.

Sheer precision for Shear Stress



The Ferranti — Shirley Viscometer is capable of giving precise measurement of apparent viscosity over a wide range of shear stress and shear rate.

The accuracy of this instrument is dependent on the low friction properties of the E.P. Specification Hoffmann Angular Contact Bearings and the rigidity which they impart to the cone spindle.

HOFFMANN

BALL AND ROLLER BEARINGS

THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX

attached to its piston rod by means of special low-expansion bushes. The high-pressure piston is of cast iron, and the alloy-steel piston rod is short and stiff and is circled by a metallic gland.

The system of air control incorporated in the L2000 unit has been developed to ensure the most efficient operational economy and, at the same time, to avoid the defects of many alternative systems in present use. The new system used employs a highly sensitive air regulator, together with a power-operated variable-volume C.C.S. intake-valve and air-interconnected high-pressure-cylinder automatic relief valve. This regulator operates accurately within 1 psi or less at 100 psi pressure, and will fully maintain the working pressure at all times. Furthermore, it eliminates all surging, either mechanical or electrical, and takes up any load variation smoothly.

Tangyes Limited

Exhibited for the first time, the new "Hydraflo" pumps exhibited by Tangyes Limited may be said to represent a complete departure from the traditional concept of reciprocating pumps, being substantially smaller and lighter and covering a wider range than has hitherto been possible with conventional units. In fact, it is expected that these new streamlined units may well replace the old type of reciprocating high-pressure pump, as, among other advantages, they have no crankshaft, no connecting rods, and no reduction gears.

Fig. 17.

The "Hydraflo" pump (Fig. 17) is basically designed for coal-infusion duties, a technique in which the coal seam is impregnated with high-pressure water before initiating coal-cutting. For this purpose, it is eminently desirable that the pumps used should be capable of high pressures and rates of flow, and that they should be mobile and suitable for handling in areas with restricted head-room. The "Hydraflo" fulfils all these requirements, as it is not only of reduced dimensions but is capable of outputs of 1000 gph at 1500 psi, or 500 gph at 3000 psi. Development of units of higher capacities is envisaged, e.g., pressures up to 6000 psi, outputs up to 3600 gph, and powers up to 50 hp.

The principle of the pump is quite simple:— Oil hydraulic power is used to reciprocate the plunger, instead of using the conventional system of gears, crankshafts, and connecting rods. As a result, the drive is "in line", and hence there are no heavy pressures on bearings and no high torques of the type associated with the design of crank-driven pumps. A large-diameter piston is used, working at a slow speed and requiring fewer cycles per unit of volume pumped. Consequently, the rate of wear on seals and valves is considerably reduced. Also, since the piston speed of the pump has a constant velocity over a complete cycle, a virtually straight-line continuous output is obtained. The electric motor is direct-coupled via a flexible coupling to a high-speed oil pump. In operation, oil is drawn from a tank through a suction strainer and is delivered to a sequence valve, which controls the flow of oil to the driving cylinder. The oil-piston assembly reciprocates and, as it is integral with the water cylinder, pumping is achieved.

All working parts are totally enclosed to prevent ingress of dirt, etc., and a strong canopy protects pipes and other auxiliaries. Controls and instruments are mounted on a panel, with adequate protection against damage. The only control on the pump is a duty-selection button.

Crofts (Engineers) Ltd.

A wide range of power-transmission equipment is only to be expected from Crofts (Engineers) Ltd., and visitors to the Exhibition are not likely to be disappointed in this respect. The list of Crofts exhibits is an extensive one, ranging from double-helical gearboxes, multi-speed geared motors and gear units, reduction gears, worm gears, and machine-cut spur, bevel, and mitre gears to magnetic clutches and brakes, self-driven conveyor pulleys, flexible couplings, "Powergrip" belt drives, hydraulic couplings, and variable-speed drives. However, major interest perhaps centres on a new type of flexible resilient coupling, known as the "Croft-Ring" coupling, and on two new types of universal-mounting gear units recently introduced by Crofts.

The "Croft-Ring" coupling utilizes radial nests of concentrically mounted split-ring springs to provide torsional resilience and to cater for angular and parallel shaft misalignments. These couplings are completely shock-absorbing and can easily be adjusted to the desired degree of flexibility.

The primary feature of the new universal gear units is their adaptability to a wide variety of mounting positions, shaft dispositions, and ratios of speed reduction. Of basically similar standardized design, and employing a single type of gear-case cast with integral feet, these units are known respectively as the Crofts universal worm reduction-gear unit and the Crofts universal helical-gear unit. In the worm reduction-gear unit, the simplified design is common to worm gears of such types as standard (worm under worm-wheel), inverted (worm-wheel under worm), and vertical (worm-shaft horizontal and wheel-shaft vertical). Up to fifty mounting positions and different arrangements of input and output shafts are possible. Modification from one assembly to another is effected by the simple interchange of oil fillers, and drain- and level-plug positions. A double-extension worm-shaft makes either right-hand or left-hand assembly possible, merely by removing the fan and cowl and replacing them on the opposite end. Sizes initially available are 4-, 6-, and 8-in. centres for powers up to 50 hp and stock ratios of 5:1 to 70:1. Smaller and larger sizes up to 14-in. centres will shortly also be available. These units can also be supplied in motorized form.

The universal helical-gear unit is adaptable to installation in any mounting position and to any combination of gears or shaft arrangement. The gears are single helical, standardized to give a wide range of ratios, with single-, double-, or triple-reduction gear trains, as required, and with parallel input- and output-shaft dispositions, or with right-angle drives using spiral bevel gears for the first reduction. Irrespective of the size or combination of gears, the input and output shafts are in the same horizontal plane, and for each size unit are dimensionally in the same disposition to each other, whether utilizing single-, double- or triple-reduction gear trains, or arranged as parallel-shaft units or right-angle drives. These units will be available in a wide range of ratios and up to 500 hp. Smaller units will be available in motorized form.

Carter Gears Limited

A wide range of working units, demonstrating standard controls for both the "A" and "F" types of Carter gears, is being shown by Carter Gears Limited. Representative of the entire range, from fractional-horse-power to 35 hp, these units include different arrangements of these variable-speed gears, electric motors, and reduction gears, and illustrate how complete variable-speed drives can be designed for the many industrial processes requiring stepless speed variation.

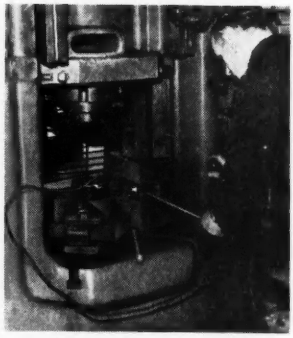
In addition, a new demonstration unit, consisting of an electric motor, an "F" type variable-speed gear, and a worm reduction gear, is being shown for the first time. The gear control is continuously operated by

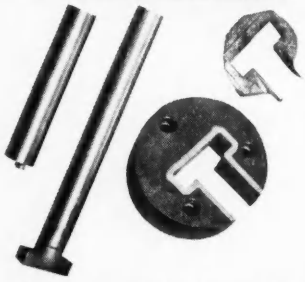
"STELLITE" ALLOYS

for heat, abrasion, corrosion and machining problems

Typical applications of "Stellite"

HARDFACING





ONE HARDFACING ALLOY FOR FORGING, UPSETTING AND CLIPPING

At the plant of Girling Limited of Cwmbran, South Wales, Ferguson Brake Rod ends are produced with "Stellite" faced dies. The machine is a Hordern, Mason and Edwards Friction Screw Press.

Smaller illustrations show the stock, finished rod, clipping tool and clipping. For more complicated work Alloy 'C' is used, and finished by machining with "Stellite" or High Speed Steel.

"Machinery" photographs by permission of Girling Limited, Tyseley, Birmingham

WRITE FOR PUBLICATIONS — B9. "Hardfacing with Deloro Stellite" **B27.** "Deloro Stellite in the Forging Industry". **B30.** "Alloy 'C' Hardfacing Rod"

AD. No. 286-G.

or send for details of "Stellite" in your particular industry

DELORO STELLITE

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DELORO STELLITE DIV. OF DELORO SMELTING & REFINING CO. LTD. BELLEVILLE · ONTARIO · CANADA

a simple cam arrangement, designed to effect a typical cycle of speed variation particularly suited to exhibition purposes. Independent tachometer drives are included in the arrangement and show both the constant input speed to the variable-speed gear and the infinitely variable output speed from the gear.

Metalastik Ltd.

Among other exhibits, Metalastik Ltd., a member of the John Bull Group of companies, are showing for the first time the "Cushyfoot" *S* mounting, one of many anti-vibration and shock mountings made by the company for locomotives, marine engines, and every type of industrial machine. This mounting incorporates an adjustable buffer to keep engine movement in all directions within desired limits. No separate devices, such as control links or snubbers, are required and, as adjustment for the buffer is at the top of the mounting, setting can be carried out with ease. With different deflections in transverse and fore-and-aft directions, the mounting is particularly suitable for locomotives. It can be positioned so that it is stiff fore and aft, but flexible in a transverse direction, to absorb engine vibration occurring in this plane. Its vertical deflection of 0·25 in. gives excellent vibration insulation for a wide range of engines and machines. Mountings with much larger deflections for shock-protection and low-frequency vibration insulation are also made by Metalastik.

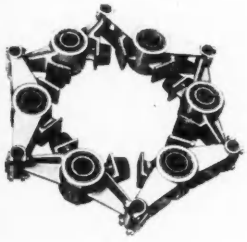


Fig. 18.

Another new Metalastik design exhibited for the first time is the torque transfer coupling shown in Fig. 18. This coupling, which is being fitted to the new Ruston & Hornsby marine engines, is designed to give increasing stiffness with torque and is particularly suitable for marine drives, reducing torque fluctuations and torsional vibrations which give rise to noise and gearbox wear. This coupling is fitted between the gearbox and the engine.

Other Metalastik couplings for marine applications include the "Double-Cone" and the "Bi-Cone" couplings, both of which transmit thrust, absorb torsional vibrations, and accommodate misalignment. Torsional vibration dampers, rubber suspensions for railway bogies, flexible bearings for unlubricated oscillating bearings, and a wide variety of components made of rubber bonded to metal are also being exhibited.

Twiflex Couplings Limited

Exhibits by Twiflex Couplings Limited, one of the Sheepbridge Engineering Group, include three working demonstration models, i.e., (1) a motor driving a flywheel through a Twiflex clutch coupling, which is run up to speed and then braked by a Twiflex disc brake; (2) a motor driving a Twiflex articulated coupling, which is worked against a pulsating load, thus demonstrating the action of the articulated linkages; and (3) a dual exhibit to show the advantages gained by using a Twiflex automatic clutch coupling on transmission systems, as distinct from a "solid-drive" installation. This exhibit is complete with instrumentation and also demonstrates a disc brake and a free overrun coupling.

In addition to a comprehensive range of clutch articulated and "Flexilink" couplings, Twiflex are including a range of industrial disc brakes and clutches. These disc brakes offer many advantages over conventional drum-type brakes, including freedom from fade, ease of maintenance, automatic adjustment for wear, and consistent braking under all conditions. A static exhibit shows a combined clutch and brake unit for a 200-hp rubber mill drive.

Another Twiflex product, not previously exhibited, is the free overrun coupling, mentioned above. Briefly, this coupling enables a drive to transmit torques in one direction and, in the event of overspeeding as a result of either the load or taking over by an alternative and/or auxiliary power unit, permits the system to "overrun" without transmitting torque back to the primary driving unit.

Laurence, Scott & Electromotors Ltd.

The two main exhibits of Laurence, Scott & Electromotors Ltd. are new types of Scott cargo winches, one for direct current and one for alternating current. The d.c. winch is a self-contained model of the well-known "Selector" winch, in which the control equipment has been simplified and the dimensions have been reduced. Thus, the contactor gear is housed in a weatherproof box mounted alongside the winch bedplate and the resistances in a compartment in the bedplate itself. This self-contained version has, however, all the original performance characteristics, giving up to about 100 fpm on full load, rising to 350 fpm with light loads.

The a.c. winch is a 5-ton "Corrector", a high-performance unit

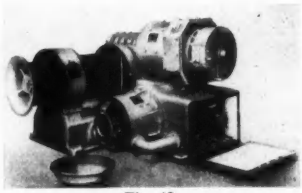


Fig. 19.

incorporating a lightweight a.c./d.c. motor-generator, so as not to impose frequent heavy current surges on the line. This winch provides a wide speed range and flexible performance by means of variable-voltage control. Full-load speed is 100 fpm, rising to a maximum of 400 fpm on light loads. Other features of this unit include electrical braking, automatic control of maximum speed in accordance with load, and automatic stopping on touch-down. The winch is self-contained, with all parts accessible for inspection and maintenance, as illustrated in Fig. 19, which shows the easy accessibility of the contactor gear and motor-generator set. Another feature of this winch is that, as all operational switching is on the shunt circuits, there are no main-current contactors subject to heavy wear.

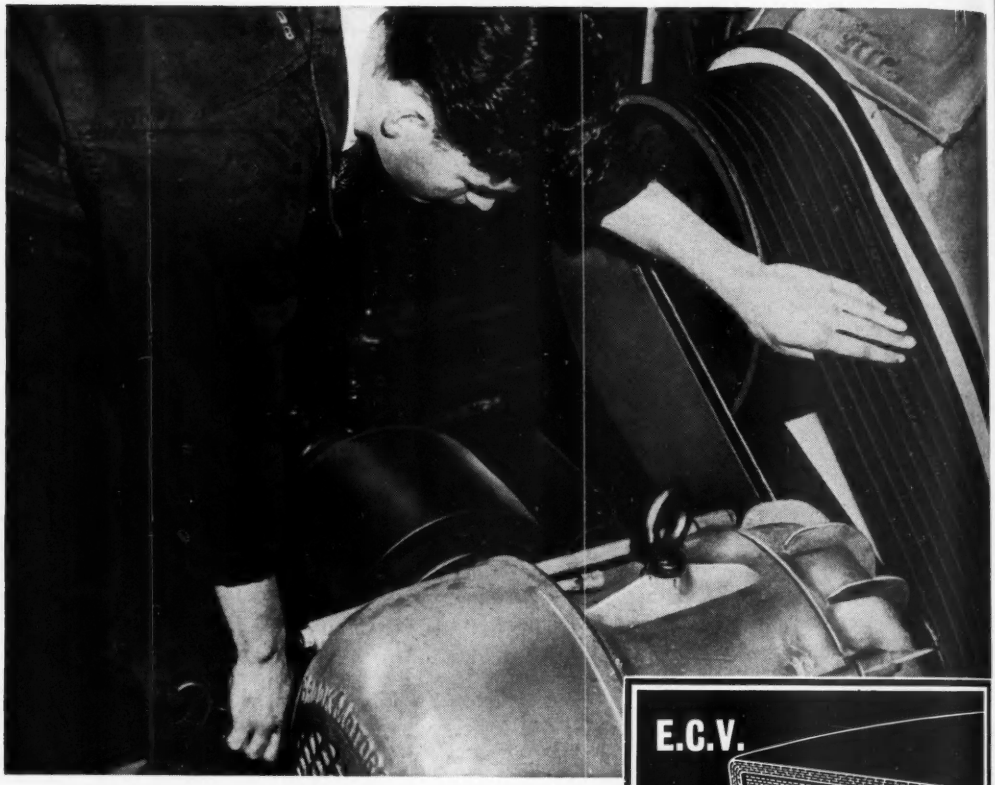
Birlec Limited

Exemplifying a new series in the well-known range of Birlec mesh-belt conveyor continuous furnaces for annealing and brazing, one of the main exhibits of Birlec Limited is a hump-back furnace rated at 20 kW and provided with a conveyor belt of 6 in. width to carry work continuously through the treatment process. This furnace has been developed for the bright-annealing and brazing of a wide range of components in stainless steel and similar materials. The conveyor belt, of woven nickel-chromium wire mesh, is driven by a special system which ensures minimum tensile stress in the heated portion of the belt, the speed of which can be varied over a considerable range. The heating chamber of the furnace is fitted with easily removable silicon carbide elements, permitting working temperatures up to 1200°C to be attained. This particular furnace, for exhibition purposes, is equipped with a standard Birlec exothermic atmosphere generator of a recent simplified design suitable for the smaller range of furnaces.

British Oxygen Co. Ltd.

Illustrating their contribution to industry, the display by British Oxygen shows how careful planning of their overall capacity to match requirements has enabled the full advantages of bulk production to be enjoyed by users of oxygen.

A feature of particular interest is an illuminated working model, measuring no less than 22 × 10 ft, illus-



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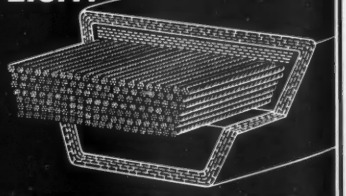
E.C.V.



BELTS FOR MULTI-VEE DRIVES

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trating the design, development, and manufacture of plant for the production and supply of industrial gases. This scale model of a simulated industrial area includes a tonnage oxygen-producing plant supplying a steelworks directly by pipeline, and also shows vehicles delivering cylinders and gas in liquid form to typical users, such as shipyards, hospitals, and garages.

Other features of the display include new and improved equipment for the storage and dispensing of oxygen and other low-temperature gases.

Kerry's (Ultrasonics) Ltd.

Among other ultrasonic cleaning equipment, Kerry's (Ultrasonics) Ltd. are showing a two-stage 40-kcs general-pupose cleaning unit designed for washing and rinsing operations in separate containers of small components, and a radial-type unit operating at a frequency of about 20 kcs and incorporating a focusing type of transducer. This latter equipment is designed for cleaning small components where a vigorous cavitation scrubbing action is required in the cleaning medium. In addition, vacuum and continuous filtration attachments for use with all the bench-mounted ultrasonic cleaners exhibited are being demonstrated, together with a general-purpose watch- and instrument-cleaning attachment. This equipment is designed for incorporation into existing watch-cleaning machines and has a cleaning capacity of approximately 2 pints.

Other exhibits include an ultrasonic soldering iron and tinning bath for tinning aluminium and its alloys without the use of a flux at a temperature below 200°C, and an ultrasonic engraving tool. This is a hand-held attachment for engraving and polishing hard and brittle materials. The actual handpiece weighs 8 oz and can be mounted on a pantograph type of engraving machine or on a drill stand, in addition to being used in the hand. An example of their well-known 60-W bench-mounted ultrasonic drill is also included among the exhibits. This particular unit incorporates a precision slide and counterbalance mechanism.

An especially interesting exhibit is a single-stage, high-power, ultrasonic impact grinding machine. This equipment is designed principally for the multiple slicing and dicing of germanium and silicon crystals, though it can also be used for any hard and brittle materials, such as ceramics, glass, semi-precious stones, etc. These machines can be supplied either as single-stage, two-stage, or four-stage units, the four-stage machine being illustrated in Fig. 20.

Sperry Gyroscope Company Ltd.

Covering a very wide range of equipment, exhibits by the Sperry Gyroscope Co. Ltd. include products intended for marine, industrial control engineering, and nuclear-reactor control and instrumentation applications. An interesting feature of the Sperry stand is that it is designed on two levels, the lower level being devoted to exhibits in the industrial and nuclear categories, while the upper level is a representation of a ship's wheelhouse, in which are installed examples of new marine gyro-compass and steering-control equipment.

Nuclear-engineering exhibits include a fine-position indicator for control rods in a nuclear reactor and a design of a complete reactor control-rod winding mechanism incorporating a number of special important features. Industrial exhibits include the Sperry precision magnetic storage drum for automatic telephone and electronic-computer applications, developed in collaboration with The Automatic Telephone and Electric Company Limited, and the "Introview" flaw and corrosion detector, now being manufactured by Sperry under licence from Imperial Chemical Industries Limited. This equipment is shown working on a representation of a steam condenser and is a high-speed non-destructive testing instrument operating on eddy-current principles and providing a permanent graphic record of abnormalities in non-ferrous metals.

Among other marine exhibits in the wheelhouse is one of the new range of "Gyro-hydraulic" steering controls developed by Sperry in collaboration with leading steering-gear manufacturers in the U.K. and overseas. A Sperry Mk. E.1. gyro-compass is also mounted in the wheelhouse, together with examples of console-type instrumentation, including the control unit of the new Sperry tiller pilot. Another interesting exhibit is a new type of bearing repeater compass stand which is fabricated as an integral aluminium diecasting, one of the largest aluminium diecastings ever made in Great Britain.

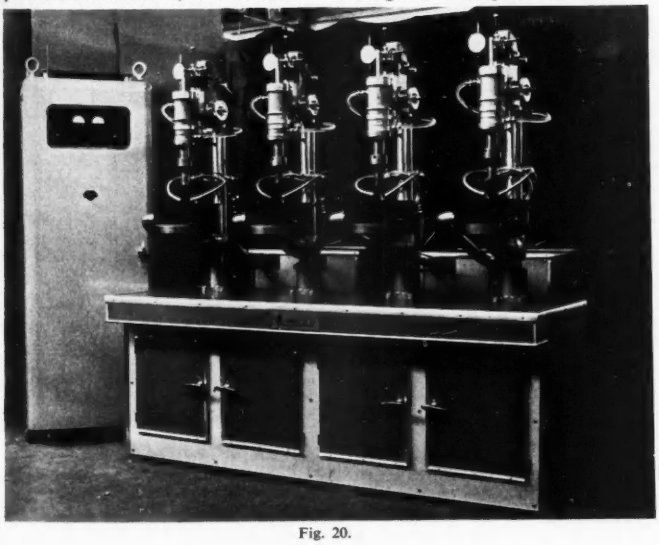


Fig. 20.

Vacu-Blast Limited

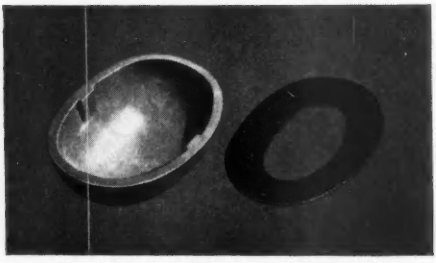
Four of their range of mobile dust-free shot-blasting machines are being exhibited by Vacu-Blast Ltd. These machines incorporate a closed-circuit pressure-vacuum system for the supply of abrasive to the work surface and for the recovery of spent abrasive, dust, and debris. The machine separates and cleans the abrasive, abstracting all dust and debris from the air stream, and it is interesting to note that actual demonstrations of shot-blasting operations are being carried out at the exhibition with the Vacu-Blast "Major", "Medium", and "Junior" machines without recourse to the use of protective clothing or special enclosures.

In order to maintain an economical blasting cycle on open Vacu-Blast applications, a further version of their Major 130 N.C. machine, known as the Major Mk. II, has been designed. This machine (Fig. 21) gives sufficient capacity for approximately 30 min open blasting, enabling a large area to be cleaned in each cycle, after which the spent abrasive can be recovered in a matter of a few minutes and blasting may then be resumed. The Major Mk. II has been designed as an all-weather model for work out of doors, but is equally well suited to indoor work, where the shot blasting of large components on the shop floor can save expensive

Here's a typical example of how the mechanical strength of Beetle D.M.C. (Dough Moulding Compound) helps to solve industrial problems.

These ear defenders are used to protect the hearing of workers in proximity to jet engines and in noisy factories. During the development work by the makers, Dennis Ferranti Meters Ltd., twelve sets moulded from conventional materials were delivered to Bomber Command for testing. The report of The Central Medical Establishment, Acoustics Laboratory, was that the ear defenders gave excellent protection, but that the mouldings then used were considered too fragile. D.M.C. mouldings were substituted and have been found virtually indestructible.

D.M.C. is the ideal material whenever high mechanical and/or electrical strength is required. The material can be moulded in conventional compression presses on short cure times and at low pressure. We shall be glad to send full technical details.



This illustration shows the main moulding from Beetle D.M.C. and a retaining piece made from Scarab material. The Earguards are used in engine testing, rivetting, blasting, rolling mills, weaving sheds, paper mills and on aerodromes.

B·I·P

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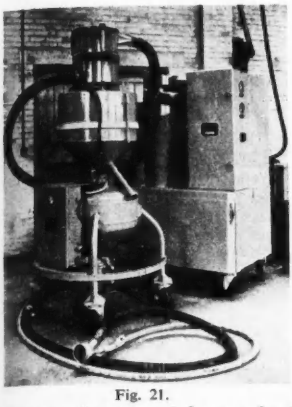

Fig. 21.

transportation to and from a fixed shot-blast installation.

Internal cleaning of pipes has long been recognized as a difficult, if not insoluble, problem, but the Vacu-Blast system has successfully been adapted to this purpose. It is now possible to provide attachments for cleaning tube bores of any size from ¼ in. upwards. The method is applicable to straight or formed pipes.

E.N.V. Engineering Co. Ltd.

Exhibits from the E.N.V. Engineering Co. Ltd. are mainly devoted to representative examples of precision gears of the type used for marine propulsion, rail traction, helicopter drives, and industrial applications, and include straight-tooth bevel gears, spiral bevel and hypoid gears in sizes from 1-in. diameter upwards, and precision spiral bevel gears with profile-ground teeth. Of particular interest is a pair of hypoid gears in hardened alloy steel, with a 6-in. offset, the wheel diameter being 40 in.

Examples of transmission and final-drive gears, mainly for industrial trucks and special-purpose vehicles, are shown, and include double-reduction axles and differential carrier assemblies, and transmission gears and gearboxes. Rail-traction gears are represented by a hypoid axle-mounted drive unit for electric and diesel rail-cars, spiral bevel gears for shunting and main-line locomotives, and precision spiral bevel gears with ground teeth, as used for a gas-turbine locomotive. Marine exhibits include narrow-angle V-drive spiral bevel gears with profile-ground teeth, as used for high-speed marine-propulsion drives with power units up to 3000 shp. In addition, E.N.V. have developed bevel gears for reactor control applications, where the requirement is for long service under high-temperature conditions and without normal lubrication, and examples of such gears currently in production for British reactors are also shown.

Self-Changing Gears Limited

A wide range of exhibits for rail-traction, marine, and industrial applications is featured by Self-Changing Gears Limited. Thus, for example, in addition to their R.14 epicyclic gearbox and their RF.28 air-operated final-drive and reverse unit, both of which are in service with British Railways, a fully automatic control for rail traction, introduced by the company, is being shown. This control, designated V.S., is intended to make the driving of lightweight diesel rail-cars a relatively simple matter by selecting a gear automatically, following a pattern which gives optimum performance. The method of selection and engagement of the appropriate gear ratios is electrical, employing two generators and a series of voltage-sensitive relays, which operate in succession to change the gear ratios through the medium of electromagnetic valves as the speed of the vehicle increases. The controller and control panel with relays are located in the driving compartment, while the generators are mounted on the output end of the gearbox.

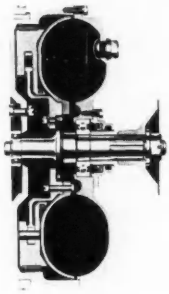

Fig. 22.

In addition to a working oil-operated marine gearbox fitted with a perspex outer casing to show the complete operation of the clutches, and an exploded model of the running gear employed in the majority of oil-operated gearboxes manufactured by the company, marine exhibits include an extremely compact oil-operated gearbox designed for unit construction with the engine, transmitting full engine power in the ahead or astern directions, as required. Another interesting marine exhibit is a coupling box. This extremely compact self-contained unit, robustly constructed of sea-water-resistant materials, is designed to couple two marine engines, thus giving the power of a larger engine and the economy of a small engine, when required. The running gear consists of five gears with ground straight spur-type teeth, and the bearings supporting these gears are of ample size, giving a good safety factor.

In addition to a range of electronic recording equipment, industrial exhibits include an exploded model of a single-stage torque converter and an exploded model of a fluid friction clutch. This clutch (Fig. 22) combines the fluid and centrifugal coupling and utilizes the best features of each type. Thus, the fluid coupling ensures a smooth take up from rest, while the centrifugal element ensures a positive grip of the friction member at high speeds, although the moving parts are comparatively light. It should be noted that no more space is taken up by the combined unit than by the normal fluid coupling.

Keelavite Hydraulics Ltd.

Although exhibits from Keelavite Hydraulics Limited include a selection of sectioned models from their wide range of hydraulic equipment, such as hydraulic pumps, motors, valves, and cylinders, emphasis has been laid on hydraulic equipment for use in marine engineering. Thus, one exhibit is a working demonstration of a hydraulically operated 1-ton winch, powered by a variable-speed drive and having a maximum operating speed of 80 to 90 fpm. The winch incorporates inching control, and the drum is driven by a Keelavite gear-type hydraulic motor powered from a Keelavite "Power Pack". Speed and directional control, together with inching and dynamic and static braking, are controlled by one lever, and the winch is fitted with a patented braking system which can only be released when the load is under the control of the hydraulic motor.

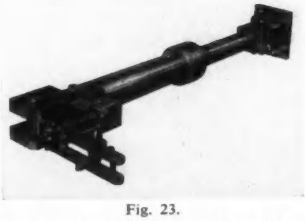

Fig. 23.

A particularly interesting exhibit, shown for the first time, is a new hydraulic steering unit designed to fit comfortably into almost any small vessel. For this unit (Fig. 23), power is supplied from a gear-type hydraulic pump, driven from the main engines or some existing drive, or powered by an entirely separate motor. The steering unit itself is very compact and consists fundamentally of a hydraulic cylinder with an integral control valve, the cylinder being operated on the "compound-connection" principle. Pressure is maintained continuously on the smaller, or annulus, area, whilst the larger full-bore area is connected either to the pressure source or to the

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reservoir, as desired. When pressure is applied to both the annulus area and the full area, the cylinder rod is forced outwards; when the bore area is connected to the reservoir, the cylinder rod will move inwards. This arrangement permits the valve mechanism to be reduced to its most simple and efficient form, since it only has to allow oil to flow in or out of one side of the cylinder.

Silentbloc Limited
Andre Rubber Company Limited

Exhibits by Silentbloc Ltd. and their subsidiary, Andre Rubber Company Limited, comprise a large range of rubber-metal products, from miniature Silentbloc units for mounting delicate instruments to rubber bearings manufactured by Andre Rubber for mounting bridges, such as the heavy-duty rubber mountings used on the Pelham and Stockport Road bridges.

Other Silentbloc exhibits include a very wide range of their anti-vibration mountings, flexible bearings, and flexible couplings, while, apart from their flexible suction entry, widely used by the Royal Navy and now available for merchant vessels, Andre Rubber is featuring the Raykin fender unit, which basically consists of a series of sandwiches of a specially developed natural-rubber compound set between steel plates. The assembled sections are arranged in an inverted V formation, so that any force acting against the fender tries to flatten out the V, putting the rubber sandwiches in shear, the resistance producing a gentle cushioning action which absorbs energy at a very high rate, eliminating risk of damage to hull plating and harbour installations. There is nothing in the Raykin fender to jam; also, it is always ready for use and requires the minimum of maintenance during almost limitless service. Components are virtually unaffected by corrosion, rotting, or ageing as, in addition to coatings of primer, multiple coatings of neoprene are applied. Sandwich assembly bolts, nuts, and washers are cadmium-plated, and the design of the fender prevents abrasion. Each fender unit is supplied as a complete assembly, so that final installation to main pier structures is simple, rapid, and inexpensive, and can be made to meet practically all problems of energy absorption in connection with harbour installations.

James Neill & Company (Sheffield) Ltd.

The main exhibits by James Neill & Company (Sheffield) Ltd. are a wide selection of permanent-magnet chucks, ranging from the small "Minor" chuck and the rectangular model for small tool grinders to large heavy-duty chucks designed to mount in adjacent positions on large machine tables, thus producing a continuous magnetic face over the full table length. Other models have fine pole spacing of the top plate for holding small parts, and there is also a range of permanent-magnet lathe chucks capable of standing up to heavy cuts and feeds and offering a speed in lathe-chuck operation not possible by other methods.

A feature is a special display of tools for the welder, including the "Eclipse" magnetic holder, the magnetic adjustable link, and the magnetic hold-fast. In addition, magnetic Vee-blocks, offering accurate and secure holding of cylindrical work, either for machining or marking out, are shown. Other magnetic tools on display are magnetic bases for dial gauges, and magnetic floaters to ease machine feeding. For the many industries associated with the electric and electronic field, a wide range of magnets for such industrial use is also included.

Industrial Hydraulics Ltd.

New products exhibited for the first time by Industrial Hydraulics Ltd. include a micro-filter, available in two sizes, i.e., 6 gpm and 30 gpm, and suitable for use in hydraulic circuits at pressures up to 1500 psi, and a liquid-sealed hydraulic accumulator, made in a range of sizes to give 1, 2, 4, 6, and 8 gpm, though larger sizes will shortly be available. A special feature of the accumulator is a hydraulic cushioning device fitted to the piston, acting initially as a dash-pot damper to eliminate shock at the end of the piston travel when oil is withdrawn from the accumulator, and then sealing off a small volume of oil, so as to prevent the piston from coming into contact with the end cover; this oil is maintained at a pressure very slightly above that of the gas charge, even though all pressure is released from the hydraulic system. During a period of shut-down, it is therefore impossible for gas to escape into the hydraulic system, since any leakage past the piston seal must be in the reverse direction under the small differential pressure mentioned.

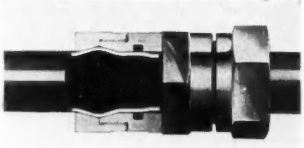


Fig. 24.

Another interesting exhibit, also shown for the first time, is the "Keelatite" pipe coupling (Fig. 24). The principle adopted in this coupling is to form the tube end to an extremely accurate shape by oil pressure, applied either by a small hand-operated pump for limited production, or a power-operated pump when large quantities are required. The operation of forming the tube takes only a few seconds, and safety features on the machine make it impossible to apply excessive pressure. These couplings can be used with any of the usual metal tubes and are available to suit a wide range of fluids and operating conditions. They guarantee perfect sealing at all pressures, irrespective of the tightness of the coupling nut and, as no weakening of the tubes takes place, thinner-wall tubes can be used, with a consequent saving in cost and weight. Furthermore, heat is not required and no machining is necessary, other than cutting the tube to length and removing burrs.

Ardleigh Engineering Ltd.

The principal exhibit of Ardleigh Engineering Ltd. is their type 500 electric governor, the first British-built electric unit of its type, developed to give very accurate control of prime-movers for a.c. generating sets.

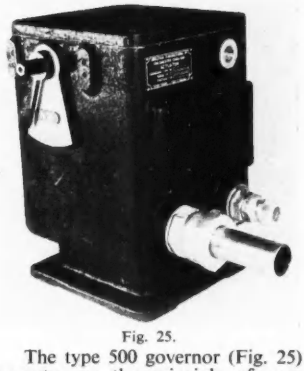
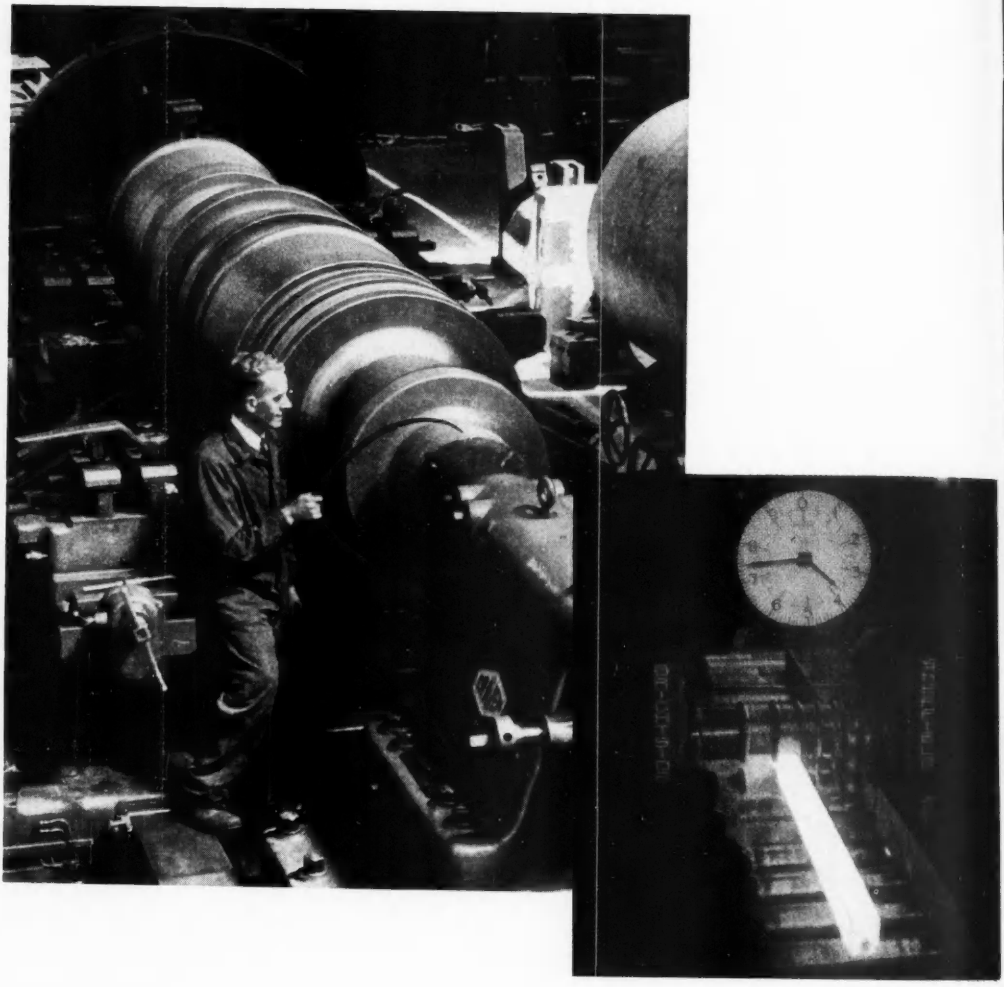


Fig. 25.

The type 500 governor (Fig. 25) operates on the principle of continuously measuring the electrical load and then positioning the throttle or fuel rack, according to the load signal produced. The positioning of the fuel rack to a new setting, as the result of a load change, takes place before the engine has time to change its speed, as the signal to the actuator is directly proportional to the alternator output. A second signal, proportional to the error in speed, then trims the fuel-rack setting and cancels any small speed drift which may occur. Consequently, response is very rapid, and a high order of speed control is achieved. When fitted with these governors, any number of sets can be run in parallel, and any ratio of load sharing between sets can be forced.

Apart from the fuel-rack actuator, which may be mounted in any convenient position on the engine, and a hydraulic-pump unit, which must be at a lower level than the actuator, the other components can be mounted in any suitable position.



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The hydraulic oil-pump unit consists of an oil reservoir, filter, pump, and a ½-hp electric motor. This unit supplies oil at a pressure of 250 psi to the fuel-rack actuator and is necessary, where an engine-driven pump is not available, to allow remote starting of the prime-mover. The fuel-rack (or throttle) actuator consists of an electro-hydraulic servo-mechanism to convert the electrical output of the amplifier unit into a mechanical movement at the required power level. Dials for controlling speed and load sharing, together with two preset controls, are incorporated in a control panel. This panel also contains the servo-oil pump-motor starter, and an over-speed trip, if required. Both the panel and the amplifier can be remote from the prime-mover and mounted anywhere convenient to the installation layout.

Desoutter Brothers, Limited

A wide range of portable pneumatic and electric power tools is being exhibited by Desoutter Brothers, Limited, and includes two new items, i.e., the type M.148 corner screwdriver and nutrunner, and the type 2SA8 reversible screwdriver. This screwdriver is the first of a series to be fitted with the new "Super Atom" motor, which produces 50% more power than the "Mighty Atom" type, but with no increase in diameter. Both these new types are fitted with the special silencer and oil-resistant plastic grip now used on "Mighty Atom" tools.

George Ellison Limited

One of the most interesting exhibits from George Ellison Limited is their new high-tension switchgear, which basically consists of an 11-kV, 250-MVA circuit-breaker unit and an 11-kV, 250-MVA oil switch. The circuit-breaker unit is only 24 in. wide and all parts are readily accessible, while its easily cleaned flush front eliminates dust traps and provides an attractive appearance. Access to the circuit-breaker is by a door with removable hinge pins, so that it can be readily detached, if required. The oil-break circuit-breaker has a breaking current of 400 A and is vertically isolated by a handle-operated mechanism, the live plugs being automatically sealed off by shutters which are positively driven in both directions. The readily accessible contact assembly is specially designed for long life and has easily renewable arc contacts and side-blast arc-control devices. The busbars are rated at 1200 A and are of unit length to simplify installation.

A terminal chamber for the transformer secondaries is at the rear of the cell. Isolation of the voltage transformer is by a handle operated from floor level, and a mechanical interlock prevents access to the interior or to the primary fuses, when isolated. Automatic shutters screen the voltage-transformer isolating sockets when in the isolated position. Up to six encapsulated current transformers may be fitted. The butt and wipe auxiliary plugs are heavily silver-plated. A terminal box for multi-core cables for auxiliary circuits is a standard fitting.

Safety precautions include a number of reliable mechanical interlocks. The circuit-breaker may be closed manually by a trip-free handle or by charging and releasing a spring, the speed of closure being independent of the operator. Closing may also be remote, by releasing a hand-charged spring, or by a d.c. solenoid or a lanyard; alternatively, the circuit-breaker may be power-closed with a d.c. solenoid.

Vokes Ltd.

Vokes Ltd., together with their subsidiary companies, Vokes Genspring Ltd. and Oxy-Catalyst Sales Ltd., are showing a wide range of products of different types. Thus, in addition to a variety of filter units, including automatic air filters, lubricating-oil filters, air-intake panel filters, fuel filters, and pipeline filters, Vokes Ltd. are showing their mobile swarf collector and a range of intake and exhaust silencers. Of these, an especially interesting exhibit, shown for the first time, is their N.C.S.P.3 splitter absorption-type silencer, which has been designed specifically to suppress the constant whine associated with the turbo-blowers of high-speed fans of either axial or centrifugal types. Special sound-absorbing material is packed behind glass cloth and is retained in position by stout expanded-metal walls, allowing for velocities of the order of 100 fps without deterioration as the result of fibrous particles being torn off. The construction of the air passages in this silencer, which is made of mild-steel sheet and welded throughout, is such that no restriction of the through area is offered.

Exhibits from Vokes Genspring Ltd. include sway braces for the protection from shock or vibration of large steam lines, feed-water lines, etc., and their "M" type of constant-support hangers for supporting pipes and ducting in nuclear power stations, refineries, chemical plants, etc. The latest hanger of this type is the "M6", which will be used for supporting CO_2 cooling-circuit ducting at the Hinkley Point nuclear power station. This type of hanger, a model of which is shown, is capable of supporting a load of 90,000 lb over a vertical movement of 4 in. Another new "M" type is the "M5", which can support 45,000 lb over a vertical movement of 4 in. Both these supports are capable of accommodating vertical travels up to 12 in. with reduced loading.

Oxy-Catalyst Sales Ltd. are showing the "Oxycat", a device for eliminating obnoxious industrial fumes, in which, basically, an oxidation catalyst is used to cause or hasten the reaction of oxidation under conditions where it would not otherwise occur. In many other applications, it can also have an important heat-recovery or fuel-conservation function. Other Oxy-Catalyst exhibits include a range of exhaust purifiers and mufflers for the elimination of carbon monoxide fumes and odours from petrol, diesel, and other equipment.

Stream-Line Filters Limited

Representative examples from their comprehensive range of equipment for the fine filtration of lubricating, hydraulic, switch, and transformer oils are being shown by Stream-Line Filters Limited, a member of the Vokes Group.

Of particular interest is the "Micro-Pak ' by-pass oil filter, to be exhibited for the first time. This filter, which is complementary to the fitting of a full-flow filter and not a substitute, removes ultra-fine peptized carbonaceous matter from engine lubricating oils, thereby ensuring that the oil maintains its lubricating function. This filter, which utilizes non-cleanable, easily renewable elements, is particularly suitable for use where detergent oils must be employed, and leaves the full-flow filter free to deal instantly with the coarser abrasive impurities.

C. C. Wakefield & Co. Ltd.

Exhibits by C. C. Wakefield & Co. Ltd. include a working model of a new mechanical lubricator, which is eminently suitable for both steam and internal combustion engines and which can readily be applied for the force-feed lubrication of all types of pumps, compressors, and other industrial machinery. The new lubricator, designated DP 60, replaces the previous DP 50 and is a precision instrument which feeds oil at a predetermined rate and in a predetermined quantity to the frictional surfaces of a machine.

The lubricator (Fig. 26) is normally actuated by the machine itself, so that the oil supply automatically commences and ceases with the movement of the machine. A particular advantage of the new unit is that a perspex tube and metal shroud, capable of withstanding a pressure of 2000 psi, replace the usual sight feed glass, which can withstand pressures of only 600 psi maximum. Furthermore, the oil reservoir is of welded steel construction, so that, for instance, in an eight-feed lubricator, a weight saving of about 29 lb is effected, compared with the usual cast-iron type of reservoir. These units are available in a range of sizes from 1 to 32 feeds, and each feed can

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Fig. 26.

be regulated from zero to maximum by a regulator screw at the front of the corresponding pump unit. Moreover, each feed has a separate flushing plunger operating independently of the pump plunger, so that full flushing feed can be obtained, irrespective of the position of the plunger. An air-vent screw is provided to each feed, to disperse air locks, should these occur when pumping commences.

The Mond Nickel Company Limited

Laying emphasis on the properties of nickel, nickel-containing materials, the platinum metals, and spheroidal-graphite iron, The Mond Nickel Company Limited has designed its exhibits to illustrate, largely by animations and demonstrations, the properties of materials containing some of their products. A wide range of technical publications is also available.

Such subjects as corrosion resistance, plating welding, strength at high temperatures, and toughness at sub-zero temperatures are covered, and numerous demonstrations are being given, including some never given before, such as demonstrations of the creep resistance of the platinum metals, of sub-zero properties, of integral-sheath thermocouples, and of apparatus for testing the corrosion resistance of materials under thermal load.

Thos. Firth & John Brown Ltd.

Exhibits totalling more than 120 tons are being shown by Thos, Firth & John Brown Ltd. and comprise a range of forgings typical of the products of their Heavy Forge department, forged-steel rolls, carbon-steel and alloy-steel bars, and a range of drop forgings by their associate company, The Firth-Derihon Stampings Ltd.

Two of the most interesting exhibits are an alternator shaft and a pair of hollow forged main gear-wheel rims. The alternator shaft, with a body diameter of 37 ft 3 in. and an overall length of 30 ft, weighs 28·1 tons and is intended for a 60-MW air-cooled, 3-phase, 50-cps, 11-kV turbo-generator operating at a speed of 3000 rpm. The shaft, which is constructed of Firth Brown low-nickel vanadium steel, has been manufactured for the Metropolitan-Vickers Electrical Co. Ltd. for the Electricity Supply Commission (South Africa) for use in the Umgeni power station. The two hollow forged main gear-wheel rims, in Firth Brown 0·32% carbon steel, have been manufactured to the order of Richardsons Westgarth for a single-screw double-reduction geared turbine to be installed in a 28,000-ton tanker. The rims are 12 ft 1 in. o.d., 11 ft 6 in. i.d., and 1 ft 8 in. wide, and weigh 3·5 tons.

Other interesting exhibits include a number of forged-steel rolls, with diameters ranging from 35 to 56 in. and weighing from 17½ to 50 tons, and a composite-type back-up roll comprising a forged-steel sleeve shrunk onto a forged-steel arbor, for use in a four-stand tandem mill being installed by The Steel Company of Wales for cold-rolling steel sheet. This roll has a barrel diameter of 53 in., is 57 in. in length, and weighs over 23 tons.

Copper Development Association

A selection of the many applications of copper and its alloys in a number of different fields of engineering is being displayed by the Copper Development Association at their attractive copper-clad stand. Many informative technical publications issued by the Association are available for inspection, and copies can be obtained on application.

An interesting working example of a hydraulic rotor jet cleaner for the automatic cleaning of tanks, vessels, etc. shows how copper alloys provide strong, accurate, and pressure-tight castings with excellent machining qualities and high corrosion resistance.

The United Steel Companies Ltd.

Dominated by a tall vertical feature in structural steelwork, the activities of the steelmaking and other branches of The United Steel Companies Limited are represented by actual products, models, or colour photographs. Thus, the Appleby-Frodingham Steel Company are featuring the production of iron and steel by means of two large colour dioramas which give a realistic impression of actual steelworks operations. They are also showing examples of sheet-steel piling, a range of bulb flats for shipbuilding, and a model of the aircraft carrier *Victorious*, which contains substantial quantities of Appleby-Frodingham plates and sections.

Forging activities form the centrepiece of Steel, Peech and Tozer's display, a large colour picture of the company's 2000-ton forging press being supplemented by small-scale models of 21 types of forging, together with coils of hot- and cold-rolled strip, a range of rolled-steel rings, and a display of nuts, bolts, and machined parts made from the company's bar-mill products.

The architectural use of stainless-steel curtain-walling is being demonstrated by Samuel Fox and Company Limited, who are also showing items made of special steels, including turbine blades and a large cylinder bolt used in power-station turbo-generators.

The Workington Iron and Steel Company, Britain's largest railmaker in acid Bessemer steel, is showing a full range of railway-track materials, including rails, steel sleepers, rail fastenings, and ballast.

Two working models are being employed by the United Coke and Chemicals Company Limited, to portray the development of "Orkot" fabric-reinforced resin. One model shows "Orkot" rolling-mill bearings, while the other demonstrates "Orkot" bushes used with a variety of lubricants. A selection of actual bearings, thrust collars, and bushes is also on display.

The construction of the stand itself contains many practical examples of the work of the United Steel Structural Company, Limited, and this is supplemented by a model of the Jodrell Bank radio-telescope, which was built by this company.

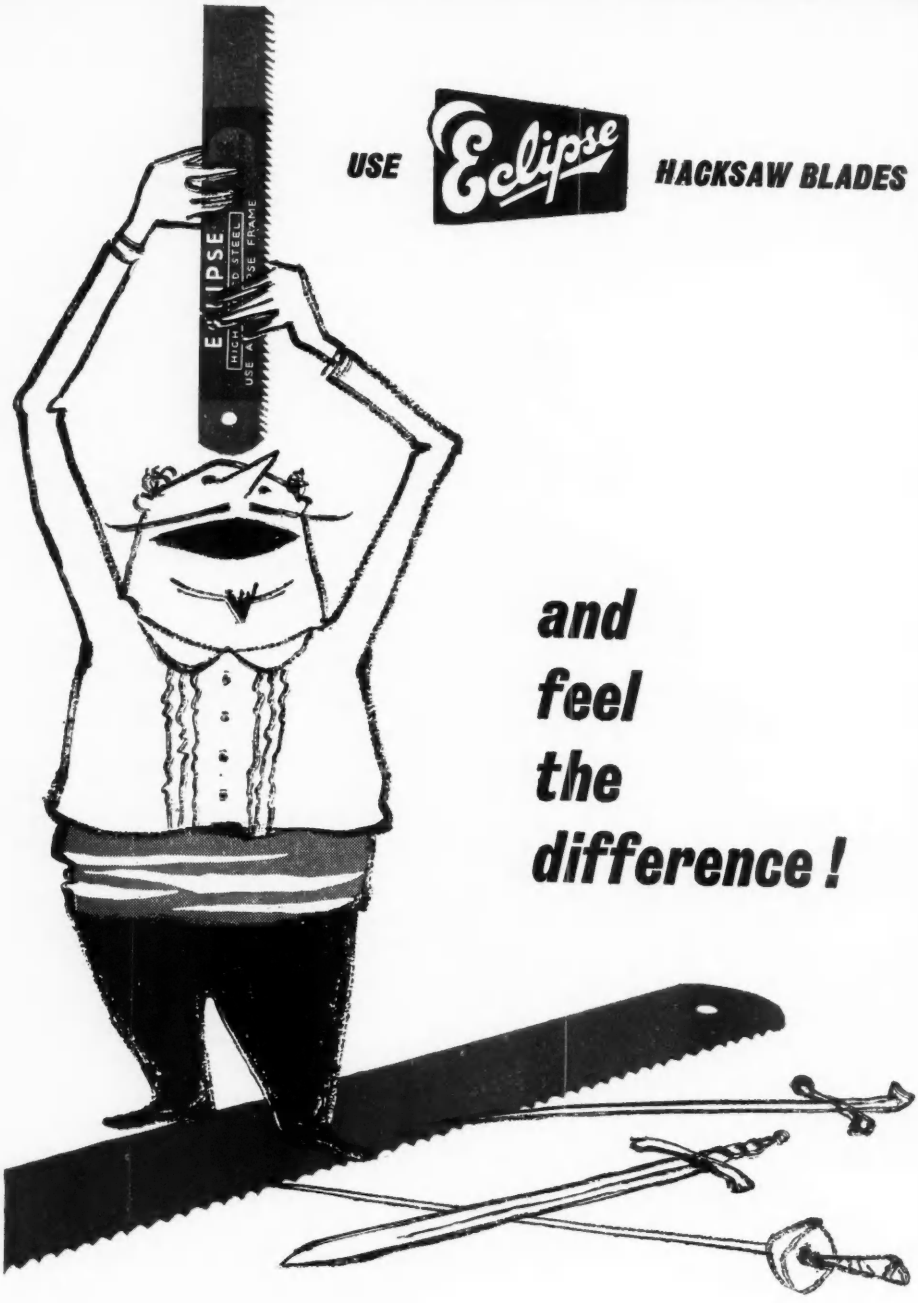
From the Distington Engineering Company, Limited, a large press-frame casting and a model of an atomic-waste "coffin" of the type used by the Atomic Energy Authority show the versatility of the company's large iron foundry. Distington are also showing a section of the new design of rope-belt conveyor which they put on the market last year.

Finally, diesel-electric and diesel-hydraulic industrial shunting locomotives made by the Yorkshire Engine Company are represented by a panel of colour photographs.

Murex Welding Processes Ltd.

A wide range of their products for the welding industry, from hand-welding electrodes to automatic welding machines, is being exhibited by Murex Welding Processes Ltd. Some of the latest models of Murex welding power-packs, mobile equipment, and welding accessories, including an extensive range of electrodes, are also on view, while a large welding booth is available for demonstrations of hand-welding electrodes.

One of the most interesting exhibits is undoubtedly that of "Muramatic" automatic welding equipment, in which versatility is one of the main features of the automatic welding head and control cabinet. The welding head can be used in the form of a single- or double-headed deckwelder and can be mounted on booms, columns, mobile platforms, etc. The head has been designed for



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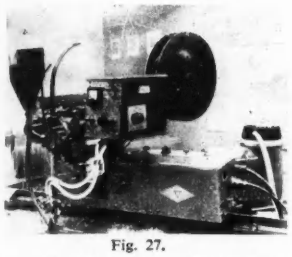


Fig. 27.

use with either the submerged-arc or open-arc process, using either a.c. or d.c. supply, and with welding currents of up to 1200 A. Attached to the head is the control panel with all the necessary electrical controls and instruments grouped together, thus permitting the operator to vary the current, voltage, and various stop, start, and speed controls, as required. Mechanical adjustments can be made to the head in all three planes for exact positioning of the electrode over the weld joint, and for fillet welding a suitable angular adjustment is incorporated.

When used on the open-arc process, the head can be fitted with a combined arc-shield and fume-extractor hood and a specially designed fume-extractor fan. For the submerged-arc process a flux hopper, as shown in Fig. 27, is incorporated, instead of the hood and extractor. Supplied with the welding head is a separate cabinet which houses the main control contactor and the auxiliary power supply circuit for operating the welding controls. The caninet is connected electrically to the welding head by a multi-core flexible cable.

Metropolitan-Vickers Electrical Co. Ltd.

Welding exhibits by the Metropolitan-Vickers Electrical Co. Ltd. include a display of arc-welding electrodes, examples of pressure-welded items, atomic-hydrogen-welded and flash-butt-welded chain links, and a Metrovick atomic-hydrogen welding set. This 50-A set consists of a sheet-steel cubicle housing a transformer, a reactor, contactor gear, and a current-tapping switch, together with a welding torch.

Another interesting exhibit is the Metrovick type RH3/17 electric resistance rivet heater, which is ready for almost instant use, the first rivet being ready within seconds of switching on the machine. The equipment shown has three heads for multiple-operator use, each head being capable of handling rivets from $\frac{3}{8} \times \frac{1}{4}$ in. to $1\frac{1}{8} \times 4$ in. at an average output of 65 pounds per hour. Separate transformers are used for each head, so that each may be set on a different tapping if more than one size of rivet is required simultaneously, and also to prevent the loading of one head from affecting the heating speeds on the others. A further advantage of this arrangement is that a transformer can be removed from one head for maintenance, without affecting the operation of the other two heads.

Quasi-Arc Limited

In addition to two new motor-generator sets and a range of welding electrodes, including the new " Ferron No. 3 " manual welding electrode, which has been specially developed for the atomic-energy industry and which deposits a weld metal of exceptionally high impact strength at low temperatures, Quasi-Arc Limited are showing their new basic automatic welding head, which enables a complete automatic welding unit to be built up from five basic assemblies combined with a suitable power source, and are also displaying for the first time in the U.K. equipment for vertical " Unionmelt " welding or slag-welding.

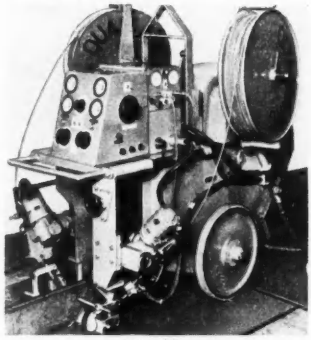


Fig. 28.

Another interesting exhibit is their automatic self-propelled twin-fillet welding machine, which is being shown equipped for " Fusarc "/CO_2 welding, though it can readily be equipped for " Uniomelt " welding, if required. This machine (Fig. 28), which has special application in the shipbuilding industry, enables two horizontal-vertical fillet welds to be made simultaneously at speeds of 15 to 26 ipm. The principal features of the equipment, apart from its speed of operation, are the deep penetration obtained, the incorporation of an automatic guiding mechanism for the welding heads, the balance and easy manoeuvrability of the machine, and its accessibility for maintenance.

Eutectic Welding Alloys Company, Ltd.

In addition to representative examples from their range of more than 150 alloys for metal-joining and overlaying applications, the Eutectic Welding Alloys Company, Ltd. are showing a number of new products, all of which demonstrate clearly this basic " low heat input " process with its surface-alloying principle, in which the base metal is not melted, but is dissolved by and surface-alloys with the low-melting-point filler metal.

The range of products shown includes flux-coated rods for joining and overlaying steel, cast iron, aluminium, copper, brass, and bronze by torch or electric arc. Among these, a new item is " EutecRod 1802 " for torch use. This high-strength thin-flowing silver-bearing alloy can be used for joining most ferrous and copper alloys. With a tensile strength of 20 tsi and suitable for butt, tee, and flange joints, this material has a relatively low bonding temperature (about 600°C) and is of outstanding value in the case of delicate or complicated assemblies, precision work, and quantity-production items.

Another newcomer is " Eutec-Bor 9 ", also intended for torch use. This super-high alloy has a low application heat range between 950° and 1050°C and is specially indicated for overlays with high abrasion and corrosion resistance and high hardness at elevated temperatures. This material is suitable for use on steel, alloyed steel, cast iron, high-chromium and nickel alloys, and some copper alloys.

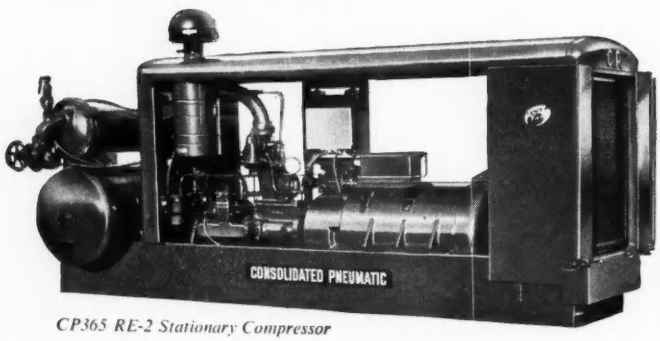
Other exhibits include the recently developed Eutectic " TinWelds " and " SilWeld 1618 ", which are combinations of alloy in powder form, mixed with specially compounded fluxes, and which can be painted onto the joint area, replacing rings or shims. For arc-welding applications, another newcomer is the " EutecTrode 6-HSS ", which provides a heat-treatable high-speed-steel overlay on tools, dies, cutting edges, and mild or alloy steels. The use of a special coating makes it possible to effect welding at the lowest possible amperage, with minimum dilution and freedom from porosity. This material retains its hardness at temperatures up to 600°C, and is ideal for building up composite blanking or punching dies and for machine-tool parts subject to heavy frictional wear.

Hancock & Co. (Engineers) Ltd.

Although an extremely interesting range of equipment is being shown by Hancock & Co. (Engineers) Ltd., including the " Hancomaster " U-arm general-purpose profiling machine, the portable " Circaline " machine for straight-line and circle cu ting and automatic welding, chain-type and gapped-ring pipe-cutting machines and flame-planing heads for cutting plate edge weld preparations, and the new " Hancomatic " dual-carriage oxygen profiling machine, there can be no doubt that major interest inevitably centres on the " Hancoline " automatic electronic oxygen-profiling machine.

Reducing upkeep costs on stationary compressors means changing over to the modern "Power Vane" rotary

Few types of plant have been the subject of such a complete change in recent years than the compressor. The switch from conventional reciprocating units to the modern rotary type of machine has brought great advantages. Simplified maintenance and lower upkeep expense are the result of eliminating pistons, crankshaft, valves and clutch. Oil cooling has resulted in safe working temperatures. Considerably reduced dimensions have resulted in compactness and lighter weight. All these features of the "Power Vane" rotary compressor have been proved in service as portable units, in recent years. Now these advantages are available in stationary plants. Designed with electric motor drives in capacities of 100, 135, 160, 300 and 510 c.f.m. F.A.D.



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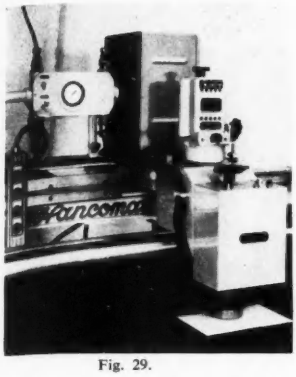


Fig. 29.

In the past, one of the most irksome aspects of oxygen profiling has been the necessity of preparing a template of steel, wood, or aluminium strip, or a drawing, carefully dimensioned to make appropriate allowance for cut width and tracing-roller diameter. It has also often been necessary to have several templates for cutting the same size of profile from various thicknesses of steel plate at no insignificant cost in preparation and storage. The "Hancoline" (Fig. 29) completely eliminates all these complications, all that is required being a simple pencil line-drawing of the workpiece of approximately finished size. The machine automatically compensates for width of cut and thus also provides for instant correction of small overall dimensional inaccuracies in profiles. The machine, which is equipped with the Hancock patented roller drive, obviating the necessity for physical contact between tracer head and drawing, will be available with cutting widths of 40, 62, 80, and 120 in.

The English Electric Company Limited

Apart from new additions to their comprehensive range of welding electrodes, The English Electric Company Limited are introducing two new items of welding equipment, these being the LWAD.600 welding rectifier and the LWC.2/300 double-operator portable welding equipment.

The LWAD.600 welding rectifier, an advanced design of portable equipment, offers the choice of two inputs, i.e., 85 to 520 A d.c. of either polarity, or 116 to 624 A a.c. These outputs are selected by means of a three-position switch situated on top of the set adjacent to the normal current-control switches. The unit has two other great advantages, inasmuch as it employs silicon rectifiers which give extremely high electrical efficiency; in addition, it is oil-cooled, thus keeping maintenance to an absolute minimum and giving very efficient cooling. The equipment is mounted on three rubber-tyred wheels and is extremely manoeuvrable.

The LWC.2/300 double-operator portable welding equipment has a welding supply of 34 to 315 A for each of two operators, or 34 to 630 A for one operator, the output of 630 A being obtained by paralleling the two outputs by means of a simple device. The unit is extremely neat and compact, easily manoeuvrable, and has the great advantage of having provision for inbuilt power-factor correction.

Lincoln Electric Company Limited

In addition to a wide range of manual welding equipment, including motor- and engine-driven generators, transformers, and rectifiers, and iron-powder, mild-steel, and alloy electrodes, together with accessories and protective clothing for all welding applications, the Lincoln Electric Company Limited are showing representative examples of their extensive variety of welding equipment and manipulative and positioning equipment.

A particularly interesting exhibit is the new Lincoln twin-head tractor for submerged-arc automatic welding, shown in Fig. 30. This unit, which has been specially designed to speed the production of fillet welds in the shipbuilding and allied industries, has two independent welding heads, each with flexibility of movement and individual controls. Each head can be used as a single unit or in combination to produce twin welds on either side of a stiffener or a similar component. The tractor is self-guiding and is readily adjustable for varying stiffener heights from 4 to 24 in., with modifications available for applications outside this range. Current adjustment, speed control, and easily-read meters are readily accessible and conveniently located for the operator, and both heads can be adjusted separately to suit varying stiffener designs and to produce continuous high-quality fillets of excellent appearance and equal leg length. The tractor, which has a speed range between 4 and 60 ipm without the need for changing gears, can be made available for both the submerged-arc and open-arc processes.

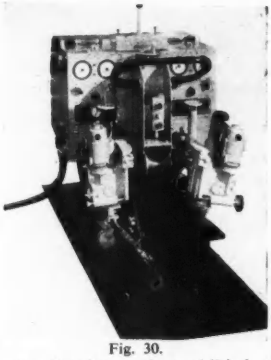


Fig. 30.

Another interesting exhibit is the Lincoln type L.R.C. travelling boom with revolving column. Fig. 31 shows this unit fitted with a "Lincolnweld" B.10 fully automatic submerged-arc welding unit, working in conjunction with a Lincoln type L.S.A.R. rotator. This versatile unit, with its counterbalanced, smooth-travelling boom mounted on its revolving column, enabling various fit-ups to be welded at any position

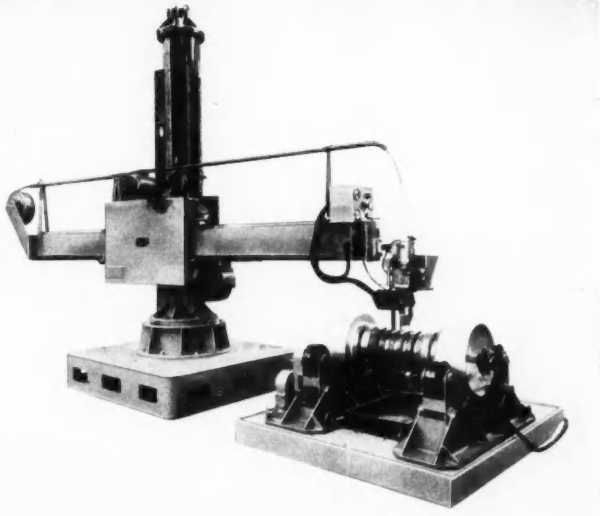
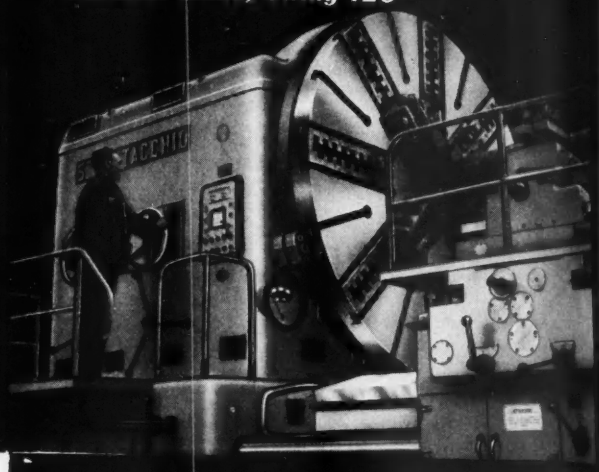


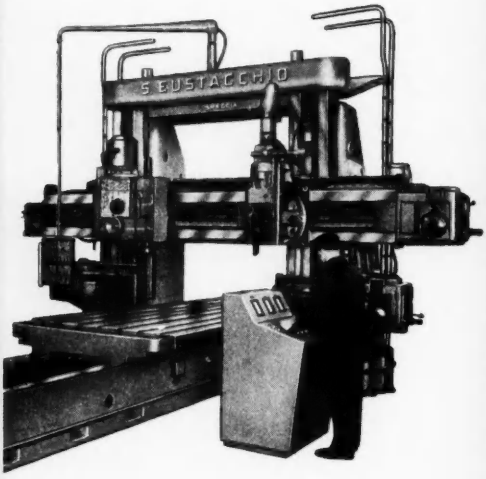
Fig. 31.

- Horizontal Lathes, Vertical Turning and Boring Mills, Face Lathes of heavy and medium size.
- Rolling Mill Roll Lathes. Special Roll Grooving Lathes with copying device.
- Rolling Mill and Paper Mill Roll Grinders.
- Heavy and medium size Planers.
- Heavy and medium Plano - Milling Machines.
- Crankshaft Roughing Lathes.
- Square, round and polygonal Ingot Lathes.

Parallel Lathe, swing 120"



Planer with planable width 80"



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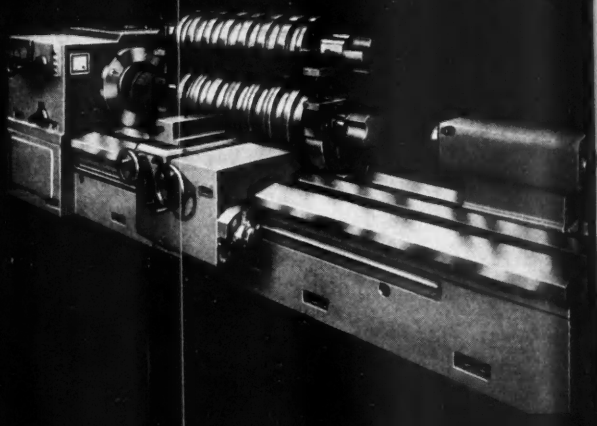

around the base, is especially designed for use with automatic welding heads, and is particularly suitable for both the internal and external welding of all types of vessels and similar fabrications.

Talbot Stead Tube Co. Ltd.

The main emphasis of exhibits from the Talbot Stead Tube Co. Ltd. is on nuclear power, numerous examples of which are shown, including a pressure vessel, breeder thermocouple guide tubes, a fuel-element support, a restraint bar, and a charge plug. In addition, scale models are shown of a control rod fabricated from stainless steel with boron inserts, and a restraint bar of mild steel, in which the outer tube has four other tubes inserted, and the centre bar is inserted into the smallest tube. Another model shows a charging standpipe assembly. Constructed of mild steel, the upper portion consists of a concrete-filled outer tube with four tubes inserted, while the lower portion comprises a large tube with a smaller tube fixed on the outer wall.

In addition to their nuclear exhibits, the company is also showing a wide range of tubes and fittings, including flanges, cocks and valves, and their patented "Swirlyflo" firetubes, which are specifically designed to jostle the hot gases against the cold tube wall along every inch of their length, as distinct from plain firetubes, which merely offer a straight, smooth escape for a core of hot gases which never come into contact with the cold tube wall. As a result, it is claimed that 6 ft of "Swirlyflo" tube can do the work of 10 ft of plain tube and can increase heat transfer by more than 60%. Furthermore, the increase in tube-wall thickness increases tube life by more than 20% and at the same time eases tube-plate stresses.

John Thompson Ltd.

The Nuclear Power Plant section of exhibits by John Thompson Ltd. is devoted exclusively to displaying the fuel loading/unloading machinery for the Berkeley nuclear power station. The John Thompson Ordnance Company are making this equipment for the A.E.I.-John Thompson Nuclear Energy Company, and for exhibition purposes the display is sectionalized into manufactured assemblies, scale models, and diagrammatical representations.

Shown as an item of the plant is the top 27 ft of the fuel chute, which is 50 ft high. In this assembly, the pressure vessel contains the top portion of a three-channel rotatable magazine and winding gear, whose two wire cables support the chute lifting grab. Outside the top section is fitted the differential gearbox, to ensure that the main cable of the

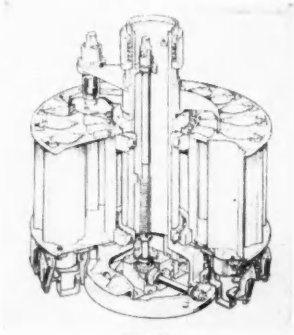

Fig. 32.

chute carries ten times the load of the secondary, or emergency, cable. Also passing through the top section and through pressure-sealed glands are the drives to connect or disconnect the grab from a load, and position latches in the magazine for supporting and clearing the various chutes. By means of a pipe at the top of the assembly, the machine is cleared of air and is filled with CO_2 gas before it is connected to the reactor vessel.

The magazine (Fig. 32), which is 4 ft in diameter, is an integral part of the fuel charge/discharge machine and enables a full load, sufficient for one reactor fuel channel, to be carried in the machine. This machine is automatically indexed and, in the case of a discharge machine, produces an empty pocket for each of the thirteen exhausted fuel elements, which it collects from a reactor-vessel fuel channel. When forming part of a charge machine, the magazine carries a fresh, new fuel element to refill a channel of a reactor vessel. Indexing of the magazine, each of whose twenty pockets are fitted with a stirrup-shaped latch on which fuel elements can rest, is by a Geneva mechanism, so as to ensure absolute accuracy in positioning. Only when there is no weight on a latch and its pocket is in line with the grab can the latch be freed to allow a clear passage down into the reactor vessel. Channels, made so that exhausted fuel elements are kept cool while in the magazine, are fitted with indicating switches to show the contents of each pocket.

Fitted on top of a differential gearbox and taking its drive from it, the fuel machine's discriminator unit is shown as a manufacture. By discriminating one against the other, it enables a magslip transmitter to indicate on the machine control panel the length of stretch at all times of the main cable. By these means, a reliable estimate of the length of the main cable's life is always available, so that exchange arrangements can be made when necessary. Additionally, by employing a second magslip transmitter to the control panel, the discriminator gearbox will indicate the actual position of the grab inside the chute machine. From these arrangements, the grab can be stopped automatically at various predetermined operational positions.

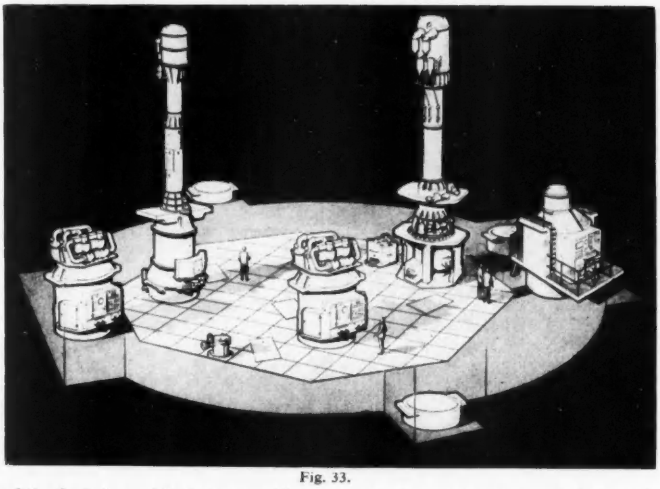

Fig. 33.

Scale models of other fuel charge/discharge machine parts exhibited are the charge/discharge machine in its entirety, visual observation and removal equipment, and the control-rod and actuator machinery. Fig. 33 is a diagrammatic representation of the fuel charge/discharge machinery for the Berkeley nuclear power station and shows (left to right) a charge/discharge machine, the fuel chute machine, a second charge/discharge machine, the control-rod-actuator servicing machine, and the visual observation and removal equipment.

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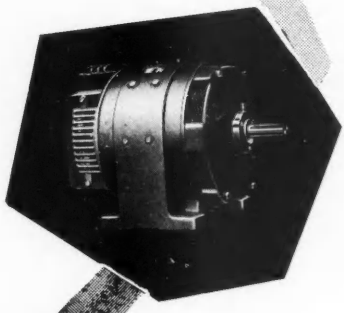

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British Industrial Developments

Precision Copy-Milling and Copy Die-Sinking Machines

A new series of "Tracemaster" machines for copy-milling and copy die-sinking has recently been introduced by Hayes Engineers (Leeds) Ltd., of Leeds 12. Of these machines, designated type TM.43, the new copy millers are heavy-duty units intended largely to replace the earlier TM.32 series, though the die-sinking version, type 32A, will be retained.

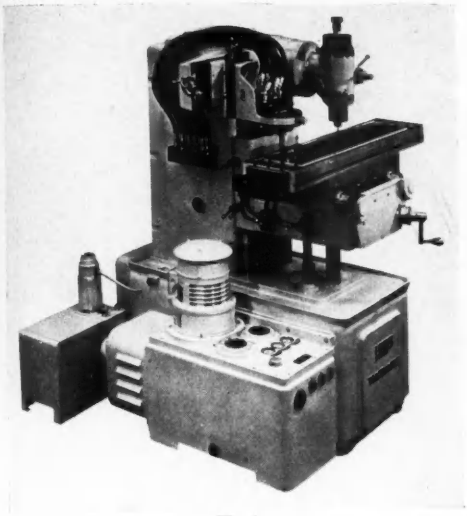

Fig. 1.

The "Tracemaster" type TM.43D is a precision vertical milling machine (Fig. 1), especially designed for 360-deg. copy profile milling, and has a table size of 43 × 11 in., a longitudinal traverse of 14 in., a cross traverse of 9 in., traverse speeds infinitely variable up to 20 ipm, and a vertical hand traverse of 12 in. The maximum distance between spindle and stylus is 20½ in., and the vertical adjustment is 3½ in. The maximum cutter diameter is ⅝ in., and nine spindle speeds are provided, ranging from 50 to 2400 rpm.

The table longitudinal and cross slides are both actuated by hydraulic rams, controlled by a Hayes "Digitrace" 360-deg. hand-controlled tracer valve, which is actually suitable for both internal and external profiles. The "Digitrace" valve consists of two tracer valves, operated by a common stylus which always remains vertical but is free to move in any horizontal direction, the amount of movement being adjustable by means of a graduated ring at the base of the valve. The amount of free movement of the stylus determines the speed of traverse. Where accuracy is important, an adequate traverse speed can be obtained with a deflection of 0·001 in. The stylus is self-centring, so that both slides are stationary when the stylus is central. The stylus is held in contact with the template by the operator and deflected in the direction of traverse required, so that it can be traversed around the template. As the operator always fully deflects the stylus, the speed of traverse is kept constant, exactly the same method being used for both internal and external templates. The tracer valve is mounted in a bracket providing considerable longitudinal and vertical adjustment, together with a small amount of lateral adjustment, considerably simplifying setting up.

The milling head is exceptionally rigid, having a positive fine feed to the quill and also a rapid traverse by means of a hand lever. The spindle is of hardened alloy steel, ground, great care being taken to eliminate all backlash between the large-diameter spline and the spiral bevel gear. The quill is also of hardened alloy steel, ground and lapped to a perfect fit in the milling head. The quill rack and pinion and worm are form-ground. Provision is made for fitting a dial indicator attachment for accurately positioning the quill vertically by means of slip gauges.

The "Tracemaster" type TM.43A is a precision automatic copy die-sinking machine (Fig. 2), designed for the economical production of forging dies, die-casting dies, and plastic, rubber, and glass moulds, etc. This machine, which also has a table measuring 43 × 11 in., incorporrates a fully automatic die-sinking cycle, and either automatic longitudinal or cross-slide reciprocation can be selected with automatic pick-up feed on the corresponding slide.

The tracer valve is extremely sensitive in operation and has a low stylus pressure. The valve controls the vertical hydraulic ram giving depth control, and the stylus assembly has a universal motion, permitting steep slopes to be copy-milled. The tracer valve also controls the horizontal traverse by means of a patented servo-system, which stops the traverse when the stylus is fully deflected. This enables vertical walls to be automatically copy-milled, and provides an approximately constant rate of traverse over the contour being milled. The use of the servo-system enables the full deflection of the stylus to be kept to a very small amount, and there is no tendency for the horizontal traverse to creep whilst copying deep vertical walls. For ease of setting up, the position of the tracer valve can also be adjusted longitudinally and laterally, and can also be swivelled.

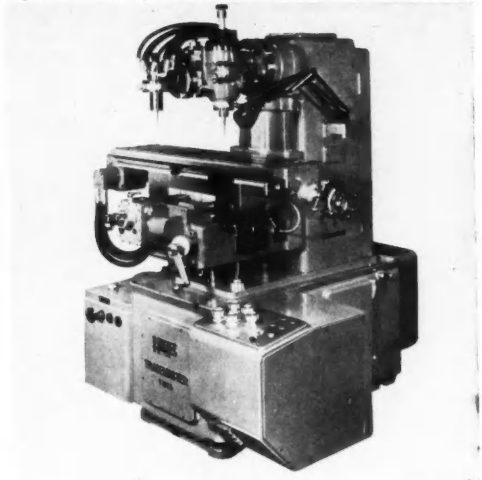

Fig. 2.

A special feature of this machine, which has a similar milling head and spindle-drive arrangements to those of the type TM.43D, is the provision of two balancing cylinders for the knee assembly. An adjustable control is provided, allowing the full weight of the knee assembly

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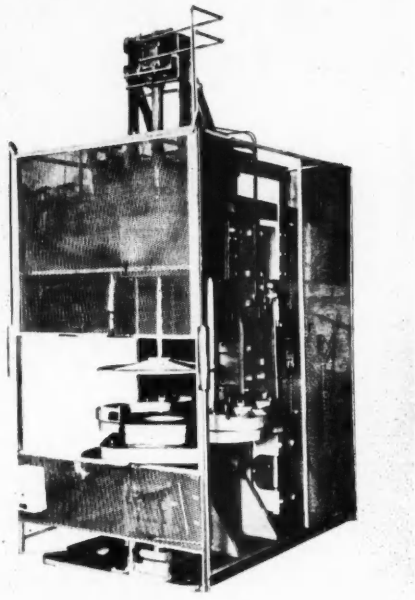
and any weight placed on the table to be exactly balanced. This ensures that the tracer valve is always working under ideal conditions, and makes the vertical hand-traverse finger-light. The hydraulic pump unit incorporates two individual hydraulic circuits, one for the horizontal feeds and the knee balancing, and one for the vertical tracing. An oil-cooling radiator and fan are fitted to keep the hydraulic oil at approximately a constant temperature. The pump unit incorporates flange-mounted pressure gauges and filters.

Heavy-Duty Irregular Double-Seaming Machines

Specially designed for the double-seaming of irregular work, the range of "Besco" heavy-duty machines announced by F. J. Edwards Limited, of London, N.W.1, is available in five sizes, with capacities from 16-in. diagonal × 20 swg to 44-in. diagonal × 14 swg mild steel. An additional model is available for seaming the taper necks of square 5-gal oil drums, this machine being provided with an extra-long clamping stroke, so as to enable the drum to be seamed over a horn and removed.

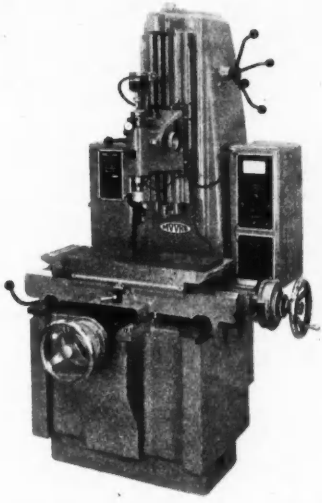
Special features of these machines include an air-operated clutch, brake unit, and hold-down. Expanded-metal guards enclose all working parts. Power is supplied by an electric motor, driving directly via Vee-belts to the drive shaft. For actuating the hold-down plate, an air cylinder is mounted above the machine. The wormwheel is keyed to the vertical spindle carrying the pressure cams and spring-loaded knock-off cam. The top arms, carrying the seaming rollers, oscillate to supply pressure on steel pins fitted to the lower arms. Adjustment pressure is applied to the arms through steel toggle links and spring-loaded slides controlled by the pressure cams.

In operation, the work is placed on the chuck, and the action of closing the gate automatically operates the hold-down and clamps the container in position. Depressing the treadle transfers the air supply from the brake to the clutch, setting the seaming cycle in operation, though this cannot be effected until the gate is closed. The flanges of the double-seam bottom and body are first curled together and then flattened. On completion of the seaming cycle, the motion is automatically stopped by the knock-off cam, and the air is transferred back from the clutch to the brake. The gate can now be opened, releasing the hold-down and allowing the container to be removed from the clutch. The seaming time on the 44-in. machine is 65 sec, and only 6 sec on the 16-in. model.



Universal Measuring Machine

As announced by the U.K. representatives, the Catmur Machine Tool Corporation Ltd., of London, W.11, a high-precision universal measuring machine has recently been introduced by the Moore Special Tool Co. Inc., of Bridgeport, Connecticut. The machine is intended for the measurement of fairly large components and for this purpose has a table size of 11 × 24 in., with 18 in. longitudinal travel and 11 in. cross travel. The spindle housing has 17 in. movement in the vertical plane, while the spindle has a total travel of 2¼ in.



An important feature of the machine is that, in addition to the highly accurate table movements, a spindle is provided which rotates with a trueness of 5 micro-inches, making it possible for the machine to explore the geometric accuracy of a workpiece. Table positioning in the two directions of travel is accomplished by precision leadscrews. As a result, the greatest error in any 1 in. in the longitudinal and cross travels is 15 micro-inches, while the greatest error over the entire length of travel is 35 micro-inches. The machine can be fitted with hand-operated or motorized leadscrews. With the power-driven leadscrews, three traverse speeds are available, one of these traverse speeds being controlled by a knob on the control panel and used only for lining up the job on the work-table. The other two speeds are controlled by a two-position switch, one of these speeds being so calculated as to obtain optimum accuracy from the use of the leadscrews for measuring. The other speed, i.e., the lowest, is used for coming up to within a thousandth of an inch or so of the desired final setting, which is then made by a hand-operated knob.

Measurement can be effected either with a universal microscope or an electronic amplifying gauge-head connected to a meter on the right-hand panel of the machine. This meter is normally supplied with divisions of 10 micro-inches and 100 micro-inches, change-over from one scale to the other being accomplished by a selector switch on the panel. In addition to the meter, recorders are available for plugging into the control panel, producing

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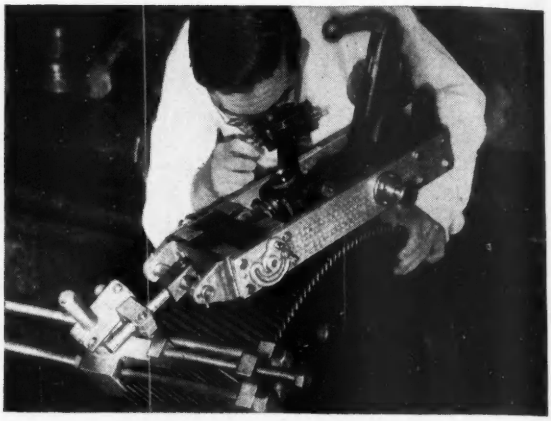

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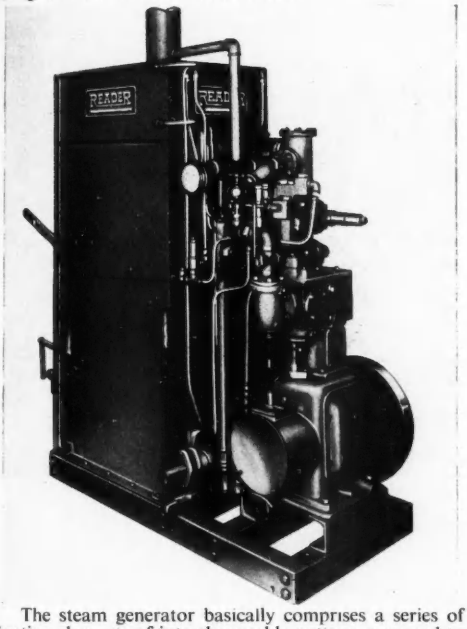
a record of roundness, displacement, etc. Two types of recorders are available, i.e., a rectilinear recorder which feeds out a continuous tape, on which deviations from the normal are shown as deviations from a straight line, and a polar chart recorder, which produces a round chart of deviations.

Among other accessories, an ultra-precision rotary table is available. This table provides an angular positioning accuracy which is comparable with that of the machine itself, as the maximum error in the entire 360 deg. of rotation is 2 seconds of arc.

Transportable Steam Power Unit

Including many design features which permit completely safe operation by unskilled labour, the Reader transportable steam-driven power unit, manufactured by E. Reader & Sons Ltd., of Nottingham, provides a versatile and compact source of power for use in remote areas. The unit is economic in operation and is capable of being sustained from local resources, including timber or agricultural and industrial wastes.



The steam generator basically comprises a series of heating elements of interchangeable pattern, arranged to permit easy access for inspection, cleaning, and descaling purposes; this feature is of importance in areas where water supplies are drawn from natural sources. To minimize the danger of explosion, the amount of water in circuit must be strictly limited, and the design adopted is therefore based on a modified monotube principle, without the use of headers or fire-drums, only a small quantity of water being in the circuit. The firebox can be arranged to suit most fuels, varying from low-grade coal, lignite, peat, etc., to wood and agricultural waste.

The engine is of the single-cylinder double-acting type, totally enclosed, of weatherproof construction, and having a minimum of working parts. The valve mechanism is arranged to permit reversal of the direction of rotation. Splash lubrication is employed, and oil consumption is negligible. In the interests of reliability, a modest speed only (450 rpm) is required to develop the normal rated output of 5 to 6 hp, but an intermittent overload to 7 or 8 hp is attainable. The piston-rod gland is of a self-adjusting pattern, and the entry of water into the crank-chamber is relatively small; this water, as well as water forming through natural condensation, is automatically drained by a device which draws off any accumulation. The flywheel, which also incorporates a driving pulley, is arranged for easy removal, and a robust, totally enclosed governor ensures close speed regulation.

The water and boiler feed-pumps are automatic, one being arranged to draw water from a convenient source and pump into the feed tank, the other delivering to the generator. All wearing parts are of easily renewable, non-corrosive materials. The control gear regulating the water feed and supply is strictly functional and does not embody any delicate thermostats or other instruments susceptible to damage. Visual indication of steam pressure is provided by a robust gauge, located in a prominent position, and a safety valve is fitted, the discharge being directed into the chimney of the steam generator. An additional safety device is also fitted, this being effective in the unlikely event of a blockage occurring in the heating elements. Adequate water straining precautions are provided, a settling tank, together with easily accessible fine-gauze filters, covering all normal cleaning requirements. With the engine running, it is impossible for the generator to be deprived of its water, unless the suction side of the pump is allowed to run dry. In this event, no danger is involved and no serious damage can result.

The steam generator, engine, etc., are coupled together to form an integral power unit, the design being suitable for use in exposed conditions. The overall weight is not excessive and the unit can be easily moved to new locations. Where mobility is important, a wheeled vehicle can be incorporated. Whilst transportability is of importance, light weight or flimsy construction would be quite unsuited for the purpose this unit is intended to fill. Consequently, a method of construction has been adopted which permits the assembly to be dismantled into easily handled component parts, the heaviest being within the accepted weight carried by two native porters.

Continuous Furnaces for Heat-Treating Transformer Laminations

Successful stress-relief heat treatment of transformer laminations in continuous conveyor furnaces has been carried out for some years by the Heat Treatment and Brazing Co. Ltd. Another such furnace, with a conveyor belt of 36 in. width, is now under construction for this company by Royce Electric Furnaces Ltd., of Walton-on-Thames, Surrey.

The average power consumption per ton of laminations treated in the furnace illustrated is 300 kWh, with requirements of 2800 to 3000 cu ft of town gas and 370 gal of water. The use of this continuous furnace installation provides a reduced time cycle, giving considerable power savings and minimizing carbon pick-up, permitting the use of an inexpensive protective atmosphere derived from town gas. Laminations, the length of which is un-

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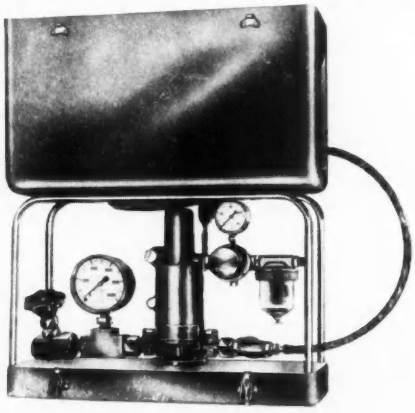
important, although their width cannot exceed that of the conveyor belt, are placed in shallow stacks directly on the conveyor, the steel spacers used in batch treatment being eliminated. Differential thermal expansion within the stacks is avoided by their minimum bulk and by uniform heat transfer from heaters distributed over the roof and hearth of the furnace. The heaters can be controlled in independent banks to suit lamination dimensions and conveyor rate, eliminating the distortion encountered in the rapid heating of bulky batch loads.

The furnace is used for heat-treatment cycles averaging 60 min. and provides for temperatures up to 1050°C, an ample margin over the normal working temperature of 820°C. A variable-speed gear of 6 : 1 ratio is incorporated in the conveyor drive. The laminations placed on the conveyor progress through a predetermined heating and cooling cycle, ensuring that all, whatever their shape or size, have an identical treatment which can be repeated, as desired. A special entrance chamber to the furnace proper has an adjustable opening to reduce protective-atmosphere consumption and is designed to purge thoroughly the laminations of oxygen and to preheat the stacks before they enter the heating chamber. The heating chamber is divided into independent zones, automatically controlled, to give close temperature control for varying weights of charge. The heating elements are of 80/20 nickel-chromium. Immediately following the heating chamber is a slow-cool section leading to a water-cooled zone, to bring the work below oxidation temperature before discharge from the protective atmosphere. The furnace is completed by fully automatic temperature-control gear and a protective-atmosphere generator.

Portable Hydraulic Test Set

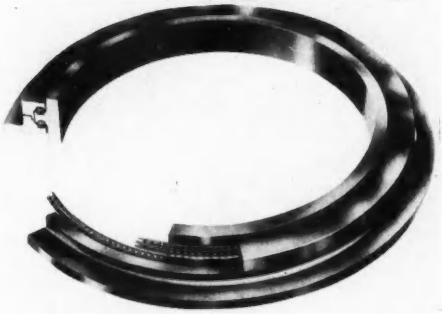
Specifically designed to cater for the needs of all those whose work is essentially mobile, the Madan portable hydraulic test set announced by Charles S. Madan & Co. Ltd., of Broadheath, Altrincham, incorporates everything necessary to carry out automatic hydraulic pressure testing on site. All that is required is a compressed-air line for connecting to the set as a source of power, but, on isolated sites where no such line is available, the set can be operated from nitrogen or compressed-air bottles.

The pump works on the principle that the air pressure applied to a large air piston imparts a thrust to a hydraulic ram of smaller area and creates a high hydraulic pressure, this reciprocating action giving a continuous flow. The set operates from a supply of not more than 100 psi. An air-pressure regulator control valve is incorporated which enables all intermediate hydraulic pressures within the range of the pump to be accurately determined and which makes it completely safe for the operator to leave the item under test, as the desired test pressure is never exceeded. On reaching the necessary pressure, the pump becomes dormant on a closed circuit, using no further air. Should there be intermittent leakage from the component or circuit under test, the pump will move automatically until the loss is made up. The complete set, which weight 38 lb, is fitted in a neat moulded glass-fibre case which, when inverted, becomes a 5-gal reservoir supplying the pump. The pump is the Madan Junior " Airhydropump ", which is available in six models, covering pressures from 50 to 10,000 psi, all these models being easily interchangeable in the test set. Pump and control valves are of non-ferrous metal or stainless steel, and all air and hydraulic packings are of the fabric-reinforced synthetic-rubber type, suitable for water, kerosene, and the majority of hydraulic fluids in regular use.



Wire-Race Anti-Friction Bearings

Available in diameters up to 13 ft in one piece, or up to 45 ft in segments, a range of wire-race anti-friction bearings marketed by the Roballo Engineering Company Ltd., of London, W.1, is suitable for use as slewing rings carrying axial loads up to 1000 tons or as continuous rotating bearings for surface speeds not exceeding 65 fps. These bearings, which use hardened wires for the ball tracks, are designed to carry axial loads, radial forces, and tilting moments in a single unit, and replace systems incorporating a "kingpin" or central pivot, thus leaving the central space free for other essential parts.



The rolling elements run on high-tensile spring-steel wires, seated in accurately machined grooves, avoiding the costly grinding necessary to rectify distortion on large-diameter rings after flame hardening and enabling the bearings to be easily and precisely adjusted to eliminate all play. A special "rolling-in" process during manufacture both hardens the surfaces of the wires and forms them to the curvature of the balls. The four areas of contact so produced (compared with two points of contact in ordinary ball bearings) give this type of bearing its ability to carry high loads in both axial and radial directions. The wire rings are not continuous, a gap of 0·02 to 0·08 in. being left, so that they fit precisely round the entire circumference of the bearing ring, thus automatically compensating for any variation in length due to an increase or decrease in temperature, without impairing the load-carrying capacity of the bearing or its smooth performance.

The rolling elements of the bearings are kept at their correct pitch by cages, separators, or spacer balls, according to conditions. The bearing balls are of high-quality, special alloy steel. The backing rings can be made of any suitable material, e.g., cast iron, stainless steel, light alloy, or even plastic. Internal or external spur gearing to suit individual requirements can be directly machined onto one of the rings to accept a drive for the rotating machinery. The rings are held together by high-tensile bolts spaced equidistantly about the ring and tapped into the upper or lower ring. A typical three-part, double-race ball bearing is illustrated.

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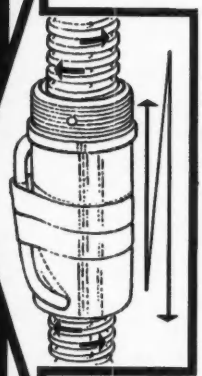

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ADDITIONAL ABSTRACTS

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The Utilization Factor of the Exhaust Energy in Turbocharged Two-Stroke Engines.

By A. STEIGER. (From *Sulzer Technical Review, Switzerland*, Vol. 40, No. 2, 1958, pp. 47–65, 12 illustrations)

THE important part played by the optimum utilization of the exhaust energy in the development of turbocharging, especially in two-stroke engines, is to-day well enough known and is illustrated by numerous publications on this subject, including a paper by Herger and Jenney in 1957, dealing, among other things, with a method of calculation of energy utilization in the exhaust systems of turbocharged diesel engines. As, however, this method is restricted to four-stroke engines, it is considered interesting to give an account of a method of calculation adopted for two-stroke engines by Sulzer Brothers.

In dealing with this problem, it has proved desirable to consider separately the conditions obtaining with pulse turbocharging and those of constant-pressure turbocharging. It should also be mentioned that the purely analytical methods of calculating the exhaust energy which can theoretically or actually be exploited in the exhaust-gas turbine in pulse operation are not discussed here.

Attention is first drawn to the importance of allowing for piping losses in the exhaust systems of turbocharged two-stroke diesel engines. The utilization factor by which these losses are characterized is then defined, and the typical differences in the calculation of these losses in pulse and constant-pressure operation are described. The concept of exhaust-energy potential is explained, and the derivation of the equations required for calculating it is given. On the basis of the results obtained in tests on exhaust-gas turbines, the method of determining the theoretical turbine work is then discussed, together with a few numerical results and a number of methods of simplifying the calculations.

Evaluation of Lens Distortion by Visual and Photographic Methods.

By F. E. WASHER, W. P. TAYMAN, and W. R. DARLING. (From *Journal of Research of the National Bureau of Standards, U.S.A.*, Vol. 61, No. 8, December 1958, pp. 509–515, 4 illustrations)

THE measurement of radial distortion in the focal plane of photographic objectives is of prime interest, as its magnitude determines the accuracy with which the final negative maintains the correct relationships among the array of point images making up the photograph of the corresponding array of points in the area photographed, this being particularly important in the case of mapping by aerial photography.

There are now three principal methods of measuring distortion, plus numerous additional methods which are either the inverse or a variation of one of the principal methods. The nodal slide bench is one of the oldest methods; this visual method is capable of high accuracy and is perhaps the most widely used. The photographic method, using a precision lens-testing camera, is more recent and arose out of the desire to make measurements under conditions approximating that of use. The third method is the goniometric method, which is used to a considerable extent in Europe.

Because of the diversity of methods used in the evaluation of distortion, it was considered useful to investigate the results of measurements made in a single laboratory on a number of lenses by a variety of methods, to determine whether or not the values so obtained varied appreciably with the method. This is being carried out for several different methods, some of the preliminary results obtained with the visual and the photographic methods being reported in this article.

It is concluded from this investigation that highly accurate values of distortion can be obtained with both methods. In fact, values can be obtained which are accurate to within ± 4 microns. When proper care is taken, the values obtained by either method do not depart from the common average by amounts exceeding ± 5 microns. It is, however, clear that, to obtain and maintain such high accuracy, it is necessary to be constantly on the alert for various sources of error, such as plate curvature, differential plate tipping, and incorrect prime calibration of angles used in the determinations.

Hole Finishing by means of Rotating Balls.

By E. G. KONOVALOV, A. M. AVRUTIN, YU. A. SIDORENKO, and I. S. LOBATCHEVSKI. (From *Stanki i Instrument, Russia*, No. 1, January 1959, pp. 29–30, 2 illustrations)

WHILST it is appreciated that finishing internal surfaces by means of plastic deformation is an effective and simple method, equipment designed in Russia for this purpose has proved to be, on the whole, unsatisfactory. It is now reported that a new process has been developed, which uses rotating balls to give an accurate and smooth finish to the bores of cylinders and other machine parts. In this equipment (Fig. 1), hardened balls (1), of about $\frac{1}{2}$ to 1 in. in diameter, are located in cages (2) and rotate around a hardened and polished collar (3), which has a taper of 2 to 3 deg. and is pressed onto a holder (4). Ball bearings (5), which support the balls sideways, abut against a plate (6) and a support (7), the plate (6) being mounted on a small shaft (8), which is fixed in position by a pin (9). This equipment can be used for holes of different diameters, the range of application depending on the length and taper of the collar (3). Change-over to larger or smaller holes is accomplished by replacing the movable parts, locking the tool by a nut (10) and a screw (11), and adjusting the tightness of the balls by an end-nut (12). When the tool is withdrawn from a finished hole, a spring (13) permits the balls to adjust themselves to the smaller diameter of the tapered collar (3).

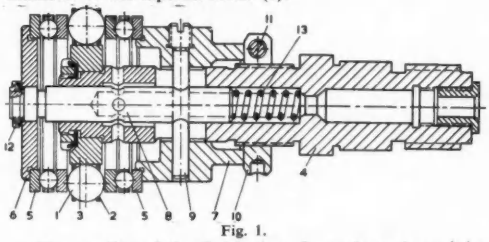
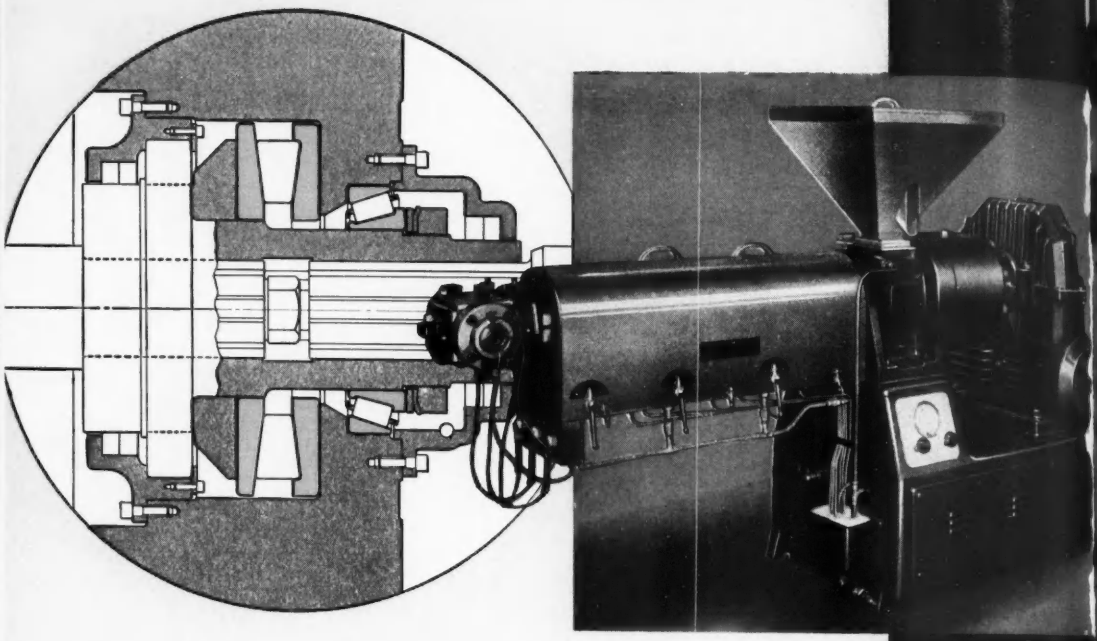


Fig. 1.

The quality of the finished surfaces depends mainly on the physical and mechanical properties of the machined components, on the quality of the surfaces prior to finishing by the rotating balls, on the feed and speed, on the diameter of the balls, and on the coolant employed. Optimum speeds, feeds, and ball sizes have been investigated, and it has been established that, with an increase in the number of balls, the permissible feed per ball and the efficiency of the equipment increase.

Apart from improving the quality of the surfaces, this equipment has made it possible to reduce the eccentricity,



Taking heavy thrust in an extruding machine

This machine, for extruding plastics, is built by General Engineering Co. (Radcliffe) Ltd. in various sizes and is illustrated without its control panel.

The extruding screw is driven by a powerful motor through worm reduction gearing.

The heavy thrust set up during extrusion is met by a Timken tapered-roller thrust bearing: this is pre-loaded by an opposing Timken tapered-roller bearing.

It will be understood that in both of these types of Timken bearing there is a true rolling action, since all the elements are conical, with suitably related rolling geometry.

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ovality, and conicity of holes by 50 to 75%; it cannot, however, entirely eliminate these defects. Since, after finishing by rotating balls, the diameters of holes tend to decrease, it is advisable to select a tool assembly with a working diameter close to the upper limit of the hole, to obtain a final size well within prescribed tolerances.

Among other applications, the new method has been tried out for finishing hydraulic cylinders of 50 to 300 mm in diameter and 1500 to 3000 mm in length. Compared with the previously used abrasive method, output has increased by a factor of 1·5 to 2, while clean and highly accurate surfaces have been obtained, and hardness and wear resistance have been increased by 25 to 30%. It is claimed that this method of finishing by means of rotating balls can often successfully replace honing.

"Traditors", a New Class of Non-Energic Non-Linear Network Elements.

By S. DUINKER. (From *Philips Research Reports, Holland*, Vol. 14, No. 1, February 1959, pp. 29–51, 8 illustrations.)

PASSIVE systems can be classified in various ways. Thus, depending on whether the differential equations by which they are described are linear or not, it is possible to divide them into linear and non-linear systems. Furthermore, it is possible to distinguish them according to the number of parts with which exchange of energy with the exterior (e.g., energy sources and loads) takes place, or according to the order of their characteristic differential equations.

A passive non-linear system may behave as an active linear system for small variations about some equilibrium position; it is then said to possess the property of local activity. If the network behaves as a passive linear system for small variations about any equilibrium position, it is said to possess the property of local passivity.

The network elements of resistor, inductor, capacitor, transformer, and gyrator, form a complete set within the domain of constant, passive, linear networks. In this paper, an attempt is made to find an extension of this set of elements, so as to make possible the synthesis of constant, passive, but locally active, non-linear networks. The analysis is based on the Lagrangian dynamical equations. It is found that a class of multiport elements, called "traditors", can be defined, these being characterized by the property that at any instant the total power delivered to them is equal to zero. The open port and the closed port, the transformer, and the gyrator can be considered as belonging to this class and as being the only linear members. Besides the latter, it is probably necessary to introduce only one other type, i.e., one with three ports, to synthesize the whole class.

Arbitrary non-linear inductors and capacitors are shown to be equivalent to combinations of traditors and linear reactors. Equivalent circuits for sets of non-linearly insulated conductors, and sets of non-linearly coupled coils can also be obtained. Traditors are shown to be locally active elements. In many cases, the introduction of traditors yields network equations which cannot be solved explicitly. No definite answer can as yet be given to the question of the physical realizability of these elements.

Induction-Ramming of a Small High-Speed Air Compressor.

By F. K. BANNISTER. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, February 13, 1959, 16 pages, 12 illustrations)

THERE is no doubt that the piston-excited pressure waves in the pipework of reciprocating engines and compressors can markedly affect performance. The investigation described in this paper is concerned with the effects of such pressure waves, or so-called induction-ramming, in the plain inlet pipe of a small high-speed air compressor. The primary objects of the investigation were to examine experimentally the influence of pipe length, pipe diameter, and compressor speed on the quantity of air delivered and the driving torque required; to analyse the wave motion theoretically and to predict its effect on air throughout; and to confirm, by indicator diagrams from inlet port and cylinder, that the pressure pulsations are as predicted theoretically.

Based on classical laws of wave motion, but using an experimentally obtained steady-flow characteristic for the inlet valve, a theoretical treatment has been developed to describe the pressure pulsations in the inlet port and cylinder and to predict the change in air flow resulting from the fitting of any particular intake pipe. Experimentally recorded indicator diagrams compare satisfactorily with those predicted theoretically, and similar agreement is obtained between the values of air flow.

As a result of this investigation, it is concluded that the fitting of a plain inlet pipe to a single cylinder may increase or decrease the throughput by up to 18%. The change in flow with a crank speed of N rpm, an effective pipe length of L ft, and an undisturbed acoustic velocity of a_0 fps depends largely on the "delay angle" $\varphi = 12NL/a_0$. Throughput is a maximum, zero, a minimum, and zero respectively when φ is approximately 80°, 155°, 190°, and 360°, the pattern thereafter repeating with diminished ordinates as φ is further increased. A very long pipe, despite its frictional pressure drop, may cause an increased flow if its length gives an optimum φ-value. Where, with moderate pipe-lengths, ramming causes an increased flow, the "gas" torque rises by a similar percentage, and the shaft torque by something smaller. Ramming is not very sensitive to moderate changes in pipe diameter or to considerable changes in delivery pressure, though each exerts some influence. "No-pipe" flow may be restored by fitting the inlet pipe with a suitable closed-end side-pipe near the cylinder.

Grinding Sulphurized Tool Steels.

By L. P. TARASOV. (From *The Tool Engineer, U.S.A.* Vol. 42, No. 2, February 1959, pp. 77–80, 1 illustration)

ONE of the principal advances in tool steels since 1945 has undoubtedly been the development of the high-vanadium types of high-speed steels and cold-work die steels. Recent developments have improved the machinability of these steels through the addition of sulphur, generally in the range of 0·08 to 0·15%, and methods have been devised to distribute the sulphur throughout the steel so that it does not have an adverse effect on mechanical properties. Free-machining tool steels have been in use for several years and enough experience has been gained to show that they have essentially the same wear resistance as the corresponding steels to which sulphur has not been added. However, no information has been published as to whether the free-machining varieties are any easier to grind.

Consequently, as described in this article, grinding tests were conducted on both the regular and free-machining varieties of three molybdenum high-speed steels containing from 4·5 to 5·0% molybdenum, 5·5 to 6·0% tungsten, 4·0% chromium, and 2·0, 2·4, and 4·0% vanadium respectively. In addition, tests were carried out on a high-chromium steel containing 1·0% molybdenum, 12·0% chromium, and 4% vanadium.

The results of these tests show that the addition of sulphur to high-vanadium tool steels to improve their machinability also improves their grindability in the hardened condition, even though experience has shown that their wear resistance remains the same. Grinding difficulty increases with vanadium content, other things being equal, but the improvement in grindability through sulphurization of the steels is greatest for those that are otherwise the most difficult to grind. The improvement is much more pronounced for dry grinding than for wet grinding, and is least when a sulphurized grinding oil is used. Thus, to the extent that the free-machining varieties of the low-grindability tool and die steels are suitable from the standpoint of the finished product, they can be advantageously used to reduce grinding costs.

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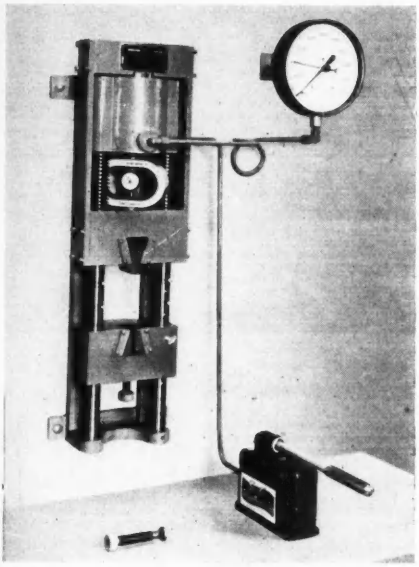
New Materials, Processes, and Equipment

WALL-MOUNTED TENSILE TESTER

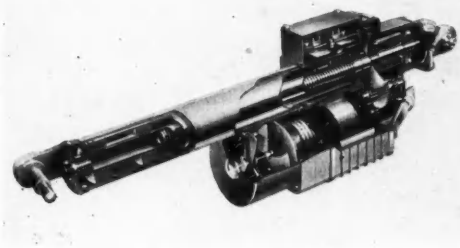
Specifically designed to save bench space, a new type of tensile tester, developed by Steel City Testing Machine, Inc., of Detroit, Mich., utilizes wall-mounted jaw units, a hydraulic cylinder, and an 8½-in. gauge, the only bench space required being for a small pump unit with an integral reservoir in the base. Tests can be made on flat or round specimens with sufficient accuracy for laboratory use and simply enough for production use.

The test specimens are gripped by hardened and ground wedge-type jaws, initial gripping force being applied by manually tightening adjusting screws. As pressure for the test builds up, the wedge shape of the jaws ensures a positive increase in holding force. The jaw-holders can be adjusted for use with specimens from 5 to 13 in. in length, breaking or yield point being indicated by a maximum-pointer carried along by the pressure-pointer on the gauge. The tester, which is available in various models, with capacities up to 40,000 lb, can easily be checked with a compression type of proving ring, placed between the moving jaw and the cylinder body, after removing the adjusting screw of the jaw.



ELECTRICALLY POWERED INDUSTRIAL ACTUATORS

The new electrically powered actuators, series 3000, for controlling mechanical movement, announced by Teleflex Products Ltd., of Basildon, Essex, are basically electro-mechanical screw-jacks which can perform similar functions to those of hydraulic and pneumatic jacks, but without some of the inherent disadvantages of the latter. Thus, for example, the electrically powered units do not require a separate power source, but are merely connected to the electricity supply, while maintenance and modifications to the system involve simple disconnection of a multi-pin and socket, no plumbing or system bleeding being required. Furthermore, because these actuators incorporate their own transmitter, signals of precise movements are relayed to the instrument panel, without the need for additional outside linkages, as is the case with pneumatic and hydraulic actuators.



The operating motor is normally wound for a 3-phase, 50-cps, 400-V supply, but motors for other voltages are available. Full-load current of the motor is less than 1 A. A low-voltage system (48 V) is used for signalling to the control room and for the indicating lamps, and a 12-V supply for the indicating system. A feature of special interest is that the actuator can be operated manually in the event of a mains failure. A plug-in handle is provided to permit independent drive, and can be used for setting up, when desired.

Power output can be set to any predetermined value and can be varied between 40 and 4000 lb. The standard stroke is 12 in. and the standard ram speed 32 ipm, though a speed of 16 ipm can be provided when requested. An overload device automatically stops the actuator and switches off the current in the event of a load higher than that specified being applied, thereby completely safeguarding the mechanism against excess loading. This patented device is of an extremely simple mechanical nature, and does not rely upon thermal switches and slipping clutches. Cam-operated switches limit travel in either direction and are adjustable to suit requirements. They are fully enclosed, and visual indication of direction of travel is given through a window. A standard fitting is a twin disc brake, electrically released, to check over-run and to provide instant and positive locking at any position of the stroke.

The actuator weighs 56 lb and has an overall length of 35 in. and a width of 5 in. The mechanism is fully enclosed and self-contained in a corrosion-resistant steel and aluminium case, remaining clean and free from fire risk at all times. The thread is fully protected by a steel outer shroud, with a wiper seal between the end-cap bearing and push rod.

AGITATOR DRIVES FOR FLUID MIXERS

The introduction of a fluid-mixing process generally necessitates the adaptation of drives which have not been designed for the specific purpose and which therefore often prove an expensive makeshift. To overcome this difficulty, the newly formed U.K. Mixer Division of Stockdale Engineering Limited, of Poynton, Cheshire, has developed the first British range of spiral bevel agitator drives, designed specifically for fluid-mixing applications. The range comprises five standard units for both open and closed tank operation, and the drive assembly can, if desired, be specially built to meet highly specialized process requirements.

The agitator shaft transmitting power from the prime mover to the impeller has been designed for maximum rigidity and minimum deflection between bearings. For

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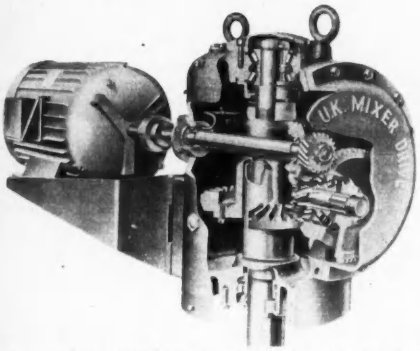
this reason, long overhung shafts can be used at speeds higher than usual, without approaching the critical or shaft whirling speed, which can set up excessive vibrations and which is the cause of most mechanical troubles in the operation of mixers. The use of spiral bevel gears, generated by the Gleason technique, ensures high efficiency, long life, and quiet and maintenance-free operation. Variable mixing speeds are required in some processes, and for this reason helical-spur "pick-off" input change-gears are fitted; these gears can be changed without removing the drive or impeller-shaft assembly from the vessel. Access is gained merely by removing the gear casing, no special tools being required. Precision spline-mounted gears are used exclusively.

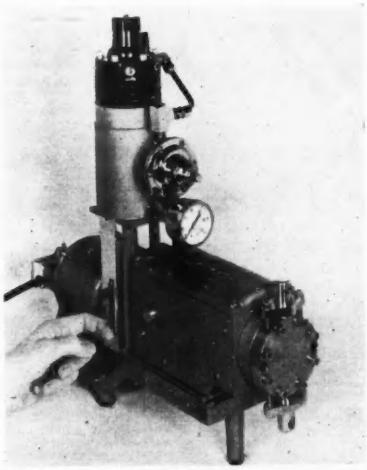


A rugged cast-iron box construction imparts maximum operational rigidity and allows the shaft to rotate without whip at the stuffing box or mechanical seal, so that little maintenance is required at this point. Furthermore, there is no danger of the packing acting as a bearing, with consequent loss of seal. Construction of the main body of the housing in one piece enhances the rigidity of bearing mountings and has the advantage of maintaining the correct right-angle setting of the spiral bevel mounting. The entire crown-wheel bearing assembly can be lifted out as one unit. A combined splash and pump-fed lubrication system provides a constant controlled supply of lubricant to the bearings and gears. Oil is retained in the gearbox by a dry-well, to prevent it from running down the shaft into the product.

AUTOMATIC METERING PUMP

An automatic metering pump which adjusts pumping rate from zero to full capacity by signals from pneumatic instruments is announced by the Process Equipment Division of the Lapp Insulator Company, Inc., of LeRoy, New York. The new pump, designated the "Auto-Pneumatic Micro-flo Pulsafeeder", is available in a variety of models, with theoretical capacities ranging from 1040 to 2300 millilitres per hour at 0 psig. Pressures up to 2000 psig can be accommodated. The pump, which is explosion-proof and designed for heavy-duty continuous service, provides a means of automatically metering chemicals without using constant-level controls, high-head tanks, measuring tanks, or stuffing-box pumps.

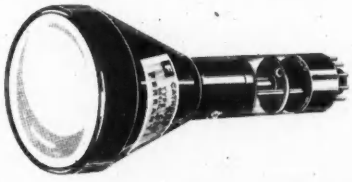
Output from 0 to 100% is controlled by air-pressure variation from instruments with a range of 3 to 15 psig. In operation, an air cylinder is integrally mounted above the stroke-adjustment mechanism, variations in air pressure (controlled by the sensing instrument) determining the position of a piston in the air cyclinder. Any change in piston position is mechanically transmitted through a cam to the stroke-adjusting mechanism, controlling pump output. Built into the air cylinder is a "positioner", which effects rapid loading and unloading of the air cylinder, to give immediate, accurate push-rod positioning in response to the slightest change in instrument air pressure. The positioner also serves to overcome friction and hysteresis resulting from such variable factors as wear and unequal loading of the push-rod caused by the reciprocating action of the pump.



The pump is of the positive-displacement type, a reciprocating piston in the pump forcing oil to move a diaphragm forward and back. The back stroke takes the liquid chemical into the reagent head through suction check valves, and the liquid is forced through the discharge valves on the forward stroke. The diaphragm isolates the chemical being pumped to an area within the reagent head plate and check valves; consequently, no other parts need be of chemically stable material. The piston does not incorporate a stuffing-box, since only oil is handled and, if a leak, however slight, exists, the oil is automatically replaced by a vacuum compensator valve. The unit may be used in conjunction with flow-orifice meters, flow-rotameters, liquid-level instruments, pH-control meters, temperature-control instruments. etc.

HIGH-SPEED CATHODE-RAY FLASH TUBES

A new range of high-speed cathode-ray flash tubes, which produce a flash of the same order of intensity as a gas-filled electronic flash tube of the type used in photography, has been introduced by the Electronics Department of Ferranti Ltd., of Oldham, Lancs. These tubes light up all over simultaneously, in contrast with the normal behaviour of cathode-ray tubes, and have the additional advantage that flashes can be repeated much more rapidly, flashes of up to one million per second being obtainable. It is also possible to produce long flashes and flashes which contain an internal fine structure consisting of a multiplicity of smaller flashes.



The new tube is likely to be of value as a high-speed stroboscope, in high-speed photographic work, in the operation of high-speed photo-electric devices requiring short flashes of light, and for time-marking on films and in xerographic processes. Another possible use lies in the measurement of short intervals of time or electrical

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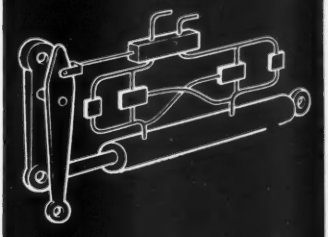

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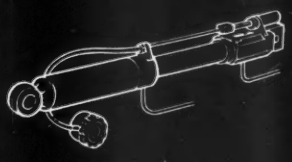

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pulses which occur in a random manner. The lamp can be arranged to flash at the beginning and end of a given interval of time or pulse; alternatively, two different coloured lamps can be used to mark the beginning and the end. The basis of this operation lies in light from the flash being shone onto a disc which is rotating uniformly at a known synchronous speed. The disc is black with a single radial white line and the two flashes will thereby produce an angle which can be appreciated in relation to a fixed scale around the outside of the disc. The flashes can be made sufficiently bright to enable the eye to retain the image for an appreciable time. A tube of this type could therefore be used for such applications as examining the bounce on relay contacts, ignition timing, and other mechanical devices. The technique is particularly suitable in instances where more than one pulse is to be examined. For this application, all that is required is the flash tube, the associated circuits for power supply, and a small synchronous motor.

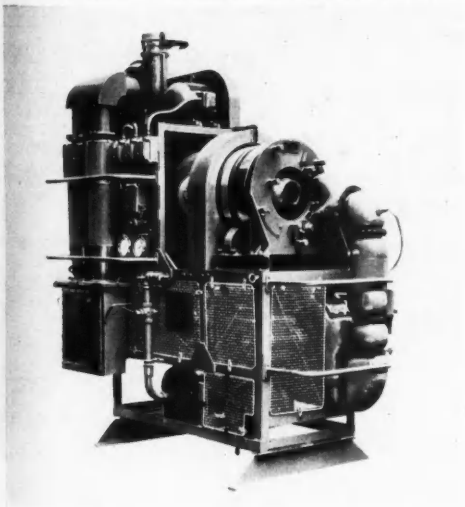
Three different types of tube are at present available. Of these, the CL60 series are triodes, 3½ in. in diameter, the CL70 series are miniaturized, 1 in. in diameter, and the CE1 series are diodes, 6 in. in diameter. Tubes can be made with phosphors of all colours, including ultra-violet and infra-red. It is also possible to produce "white" light free from the spectral line structure associated with gas-discharge lamps and extending over specified spectral ranges. An interesting application of this vacuum type of flash tube is its use, in conjunction with Ferranti solar batteries, in the examination of binary or other position-indicating scales at high speed. By a suitable choice of phosphor, the characteristic emission of the flash tube can be made to match the peak sensitivity of the solar cell.

SMALL SELF-CONTAINED DRYING UNITS

A small self-contained drying unit suitable for processing a wide range of materials in the form of powders, filter-cakes, granules, etc. has been produced by Dunford & Elliott Process Engineering Ltd., of London, S.W.8, as a packaged version of their rotary-louvre continuous dryer. The new model is a compact and versatile unit which can be used for carrying out tests as a preliminary to full-scale processing or for the rapid and continuous handling of small quantities of materials. In addition to drying, it is capable of roasting and cooling.

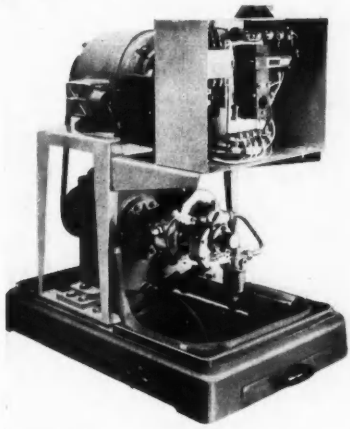
The dryer has a holding capacity of approximately 1 cu ft maximum of material, and the drying time can be varied between 5 and 60 min to suit the moisture content and the type of material to be processed. It is estimated that under favourable conditions the unit is capable of evaporating 100 lb per hour of free water; on a basis of the above holding capacity and drying times, it will handle between 1 and 12 cu ft per hour of material.

The installation consists basically of a rotary-louvre horizontal drum, mounted on four adjustable supporting rollers and driven by a ⅛-hp motor through a single-reduction gearbox, two fans (inlet and exhaust, powered by a 1-bhp motor with a Vee-rope drive), a direct-type air heater with a combustion chamber fitted with a burner and hand control-cock, and a high-efficiency dust collector attached to the exhaust hood. The instruments fitted include an air-flow measurement device and temperature indicators for both the inlet and exhaust. All parts of the drum coming into contact with the material are made of stainless steel, the life of these parts being very long, owing to the complete absence of abrasion. Maintenance costs are therefore reduced to a minimum. The dryer is supplied ready for operation, all that is necessary being to connect one electrical point and one gas point. Heating arrangements by means of electricity, oil, or an indirect air/steam heater can be provided, if required.



OIL-FIRING UNITS FOR BOILERS

Available in seven models, with maximum fuel rates of from 36 to 260 lb/hr for the oil-firing of boilers with ratings from 450,000 to 3,300,000 BTU/hr, the new "Macfire" units announced by Urquhart's (1926) Limited, of Perivale, Middlesex, utilize medium-pressure air atomization, natural draught, and a light grade of residual fuel oil, and are stated to overcome the practical problems of noise level, installation, and first costs inherent in such a specification.



The complete Macfire equipment, which is neat and compact in design, consists of an attractively styled fibre-glass resin-bonded free-standing cabinet for housing all the auxiliaries, a boiler front-plate assembly, similarly housed in a fibre-glass cover, and a set of pipework for interconnecting on site. The cabinet unit contains an electric motor, which drives an air compressor fitted with an air-intake silencer, and which is directly coupled to a volumetric fuel-metering pump. The pump is provided with a hand adjustment, so that it may be set for the required fuel rate, which is kept constant, irrespective of fuel temperature, suction, or pressure head. A built-in fuel filter is fitted, and a pneumatic cut-off valve safeguards the flow of oil in the event of air-pressure failure. The heart of the control-system wiring is a printed circuit, to which is connected the electric-motor starter, a heat motor which controls the cycle of operations, and the flame-failure relay circuit. A high-tension transformer

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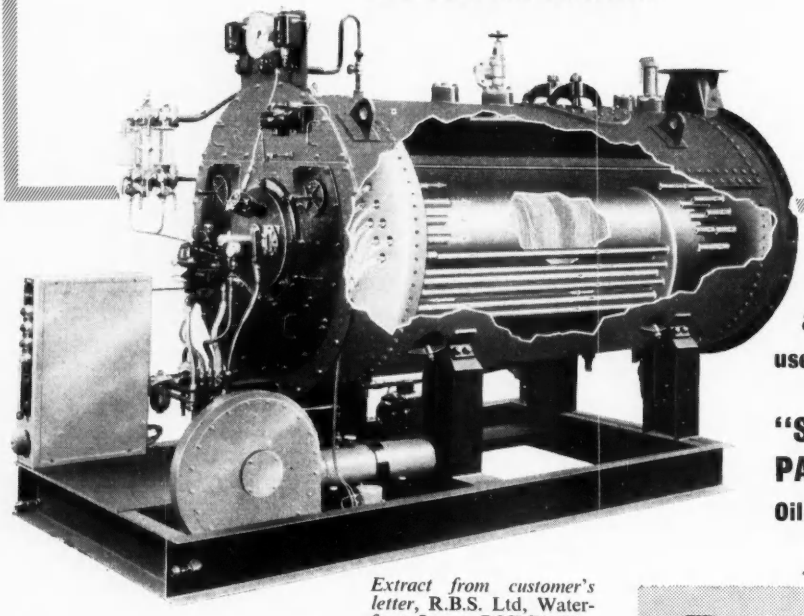

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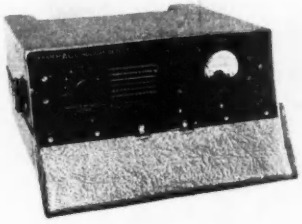
is provided for the ignition system. The cabinet unit, with the fibre-glass cover removed, is illustrated, showing the assembly of electric motor, compressor, volumetric fuel pump, and the electrical wiring and equipment.

The boiler-front assembly houses the radiation toe-heater, saving on the cost of preheating fuel by the elimination of a line heater. A built-in 40- or 75-W heater provides a small reservoir of preheated fuel for instant starting from cold. Fine atomization of the fuel is by means of a medium-pressure (8-psig) air system, ensuring complete combustion immediately from starting up. Also in this housing is an automatic pull-back device which withdraws fuel from the atomizer orifice on shut-down, so as to prevent dribble. A built-in photoconductive cell for flame-failure control eliminates the conventional amplifier section and energizes the relay in the cabinet unit. The higher noise level inherent in medium-pressure air systems is suppressed by a front-plate cover which acts as an attenuator.

PORTABLE HIGH-VOLTAGE DETECTOR FOR FAULTS IN INSULATING MATERIALS

A fully transistorized instrument, designed to provide a source of high voltage for detecting imperfections in the insulating properties of protective materials applied to metal structures, has been designed and developed by P.A.M. Limited, of Guildford, Surrey, in conjunction with Cathodic Corrosion Control Limited. Known as the Portable Holiday Detector, the instrument weighs approximately 17 lb complete with batteries. In the form shown, the detector is contained with batteries in a strong plastic case, which is carried in a shoulder harness worn by the operator when carrying out tests on coatings applied to pipes. The overall dimensions are 11 × 9½ × 4½ in.

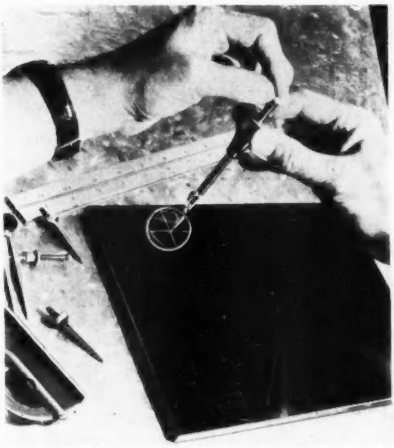


The output voltage is direct current of negative polarity, adjustable in eight fixed steps between 6 and 20 kV by means of a selector switch. Up to 500 μA can be drawn from the unit at 16 kV. A built-in meter provides an accurate indication of the output voltage. Input power is supplied by six 2-V non-spill batteries, which give up to 12 hr continuous operation before recharging becomes necessary. Various types of high-voltage probes can be connected to the detector for different purposes, to suit individual requirements. The presence of a crack or fault in the insulating material or coating under test produces a loud penetrating note from a small built-in loudspeaker in the detector, the note varying with the extent or character of the fault located. The instrument can be preset to operate over the range from short-circuit fault current down to a maximum sensitivity of 100 μA, representing leakage current.

In addition to the sound indicator, a specially designed controllable neon-lamp indicator can be fitted to the electrode handle, covering the same range of leakage current from 100 μA upwards. The unit can thus be used to indicate coating thickness, as well as actual defects.

COMBINATION HAMMER, CENTRE-PUNCH, MAGNIFIER, AND SCRIBER

A combination hammer, centre-punch, magnifier, and scriber, developed by the Langley Corporation, of San Diego, Cal., is a high-precision tool for machinists,

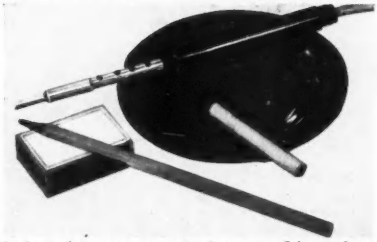


template makers, designers, engineers, tool and die makers, maintenance men, etc.

Centre-punching is facilitated in laying out centres of measurement by the use of the new tool, the magnifier clearly showing hundredths scale graduations for higher accuracy and precision. For rapid centre-punching, the tool, designated " Centa-Scribe ", is assembled with the hammer raised. The centre to be used is then located, and the hammer dropped from the top of the handle, producing an accurately located centre, ready for further enlarging or drilling. A useful accessory is a carbide-point scriber, which is easily attached and which facilitates scribing on glass, ceramics, hardened steel, or other surfaces.

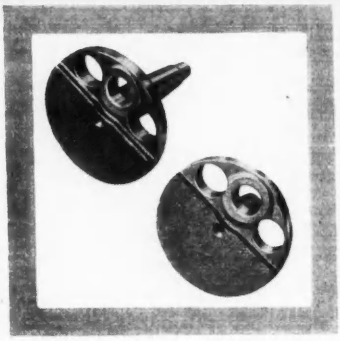
SUB-MINIATURE ELECTRIC SOLDERING IRON

Although weighing about 1 oz and of almost pencil-size dimensions, the new type SMS sub-miniature soldering iron announced by the Electrical Remote Control Co. Limited, of Harlow, Essex, is a highly efficient unit retailing at about half the price of the average mains-type soldering iron of ten times its weight, but is claimed to have a better performance with half the consumption. Thus, for instance, it is stated that the new iron, which is available with alternative element ratings of 10, 15, 20, 25, 40, 55, and 75 W, is capable of soldering 8-gauge copper wire, 10-gauge brass sections, or 16-gauge mild-steel sheet—work for which mains-type soldering irons of from 100 to 150 W have previously been used.



A choice of twenty standard types of interchangeable soldering bits, with tips of from $\frac{1}{16}$ to $\frac{5}{16}$ in. diameter, is available, and, with the elements of lower ratings, the iron is eminently suitable for the mass production of television, radio, and other electronic or transistor assemblies. Providing absolute safety from electric shock and less fatigue to operators, the iron has the stem and copper bit completely insulated from electrical connections, while the handle, which always remain cool, is provided with a hexagon anti-roll guard.

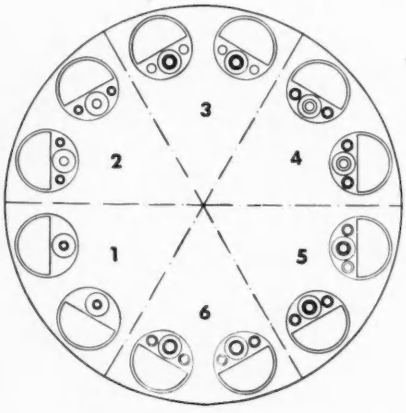
VERTICAL DRILLING MACHINE



VC III G

multiple spindles on jig bored support plate.
Floor to floor time for 2 pieces: 52''

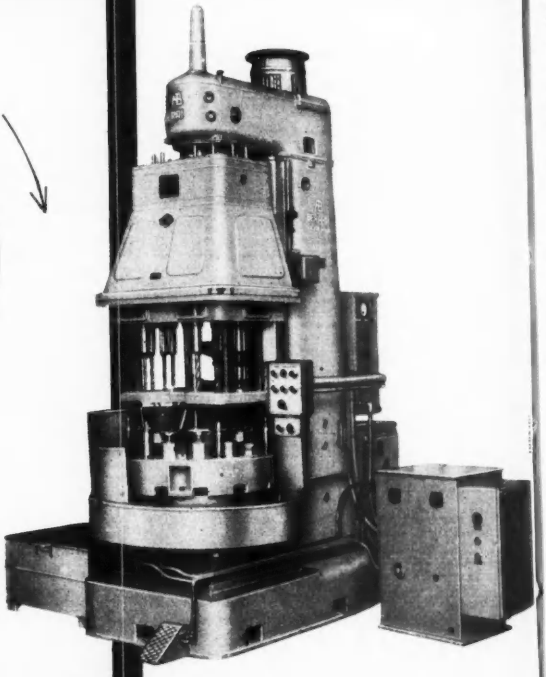
Machining cycle



load station

Components: crankshaft shoulders, pinion and flywheel ends.

Station	1	**Operation** Drill central hole
	2	Drill lateral holes
	3	C' sink (both sides)
	4	C' sink (both sides)
	5	Ream central hole
	6	Load and unload



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(Associata all' U. C. I. M. U.)

59/5 1

BERARDI

NEWS OF THE MONTH

PERSONAL

Mr. L. C. Burke has been appointed chairman of the board of directors of Standard Telephones and Cables (S.A.) (Pty) Limited, of Johannesburg, South Africa.

Mr. Laurence Malec, M.B.E., A.R.Ae.S., has joined The Solartron Electronic Group, Ltd. as managing director of Solartron Radar Simulators, Ltd.

Mr. T. Sanderson, general works manager, and **Mr. J. Laird,** commercial manager, have been appointed to the board of the Workington Iron and Steel Company. **Mr. J. N. St. George Curwen, Mr. Langton Highton,** and **Mr. D. R. Wattleworth** have retired from the board of this company and from the boards of other subsidiary companies of The United Steel Companies Limited.

Mr. J. A. Holloway has been appointed sales manager of the switchgear department of the Simplex Electric Co. Ltd., of Oldbury.

Mr. Donald Lambert Brown, M.I.Mech.E., A.M.I.C.E., M.I.Gas.E., A.F.R.Ae.S., has been appointed deputy manager of the research department of Smiths Aviation Division at Cheltenham.

Mr. A. A. Haining, former deputy sales manager of Sigmund Pumps Limited, has been appointed sales manager of Exactor Limited, of Edgware, Middlesex.

F. Perkins Limited announce the appointment of **Mr. J. G. Dawson, B.Sc., M.I.Mech.E., A.F.R.Ae.S., M.Inst.F.,** as director of engineering, and of **Mr. Geoffrey Smith, M.A. (Cantab), A.M.I.Mech.E., A.M.I.E.E.,** as director of production.

Mr. J. Yates has been appointed manager of Clarkson Engineering (Canada) Ltd., and will be operating from their Toronto office at 767 Warden Avenue, Scarborough, Toronto.

Mr. R. D. Baird, B.A., E.R.D., has been appointed a director of Baird & Tatlock (London) Ltd. and of Hopkin & Williams Ltd. **Mr. R. T. Beasley** has joined the B.T.L. Group of Companies as personnel manager.

Mr. S. J. Morris, former general works manager at Castleford, has been appointed general manager of the Charlton glass-container works of United Glass Ltd.

D. Napier & Son Limited have appointed **Mr. J. F. W. Bowskill** as their resident technical representative for South, Central, and East Africa, in succession to **Mr. P. S. Deary.**

George Ellison Limited announce the appointment of **Mr. A. H. Lothian** as sales and technical representative for Ellison hydraulic valves in Scotland and the extreme North of England.

Mr. J. Douglas Elstone has been appointed director of marketing of the tractor division of David Brown Industries Ltd., at Meltham, Yorks. **Mr. W. A. Griffin** has been appointed area sales engineer (South Wales) of the industrial gear division of The David Brown Corporation (Sales) Ltd.

Anti-Dust Services Ltd. announce the appointment of **Mr. J. G. Marsden** as general sales manager in charge of U.K. sales.

Mr. A. Cormack has been appointed superintendent (special duties), Larne Works, and **Mr. R. Harrison,** assistant superintendent, Germiston Works, of the Metropolitan-Vickers Electrical Company Limited.

Mr. F. C. Boys has been appointed commercial assistant to the product manager of the electro-acoustics department of Philips Electrical Ltd.

The Council of Iron Producers has elected **Mr. N. C. Macdiarmid,** managing director of the Stanton Ironworks Company Ltd., and a member of the Joint Iron Council, as their chairman, in succession to Sir Frederick Scopes.

Mr. H. G. Herrington, C.B.E., managing director of High Duty Alloys Ltd., has been elected chairman of the Aluminium Industry Council for a third term of office.

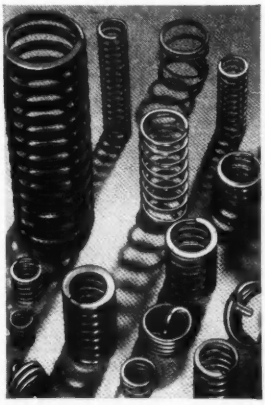
BUSINESS NOTES

Teleflex Products Ltd. announce that their mechanical-handling division has moved from Chadwell Heath to a new factory at Basildon New Town, Essex. The new plant, which is adjacent to the remote-controls division of the company, occupies 50,000 sq ft, with adequate additional land for further expansion.

Martonair Limited, of Richmond, Surrey, manufacturers of pneumatic equipment, have opened an office at 66 Mosley Street, Manchester 2 (Tel: CENtral 0032).

Monks & Crane Ltd., of Garretts Green Lane, Birmingham 33, have been appointed distributors for Holo-Krome special alloy-steel screw products.

The Incandescent Heat Co. Ltd., of Birmingham, have obtained exclusive selling and manufacturing rights in the United Kingdom for all products of the Swenson Evaporator Co., of Harvey, Illinois, including evaporators, crystallizers, and spray driers. Headed by Mr. C. J. V. Denning, a chemical-plant division has been formed to handle these products and other thermal equipment for chemical process plant.



Where MAXIMUM RESISTANCE to HEAT, Fatigue and Corrosion is vital . . .

The design and manufacture of high duty helical, compression, extension and torsion springs possessing exceptional resistance to heat, fatigue and corrosion is the particular speciality of the Lewis Spring organisation. Coil springs can be made in stainless steels (18/8 Austenitic), high nickel alloys (Inconel), Copper Alloys (Beryllium Copper), Alloy Steels (Chrome Vanadium), Molybdenum and plain carbon steels.

Why not call us in *at the beginning* of your next project? You'll be surprised at the number of technical headaches we can help you to avoid.

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RESILIENT WORKS, REDDITCH
London Office:
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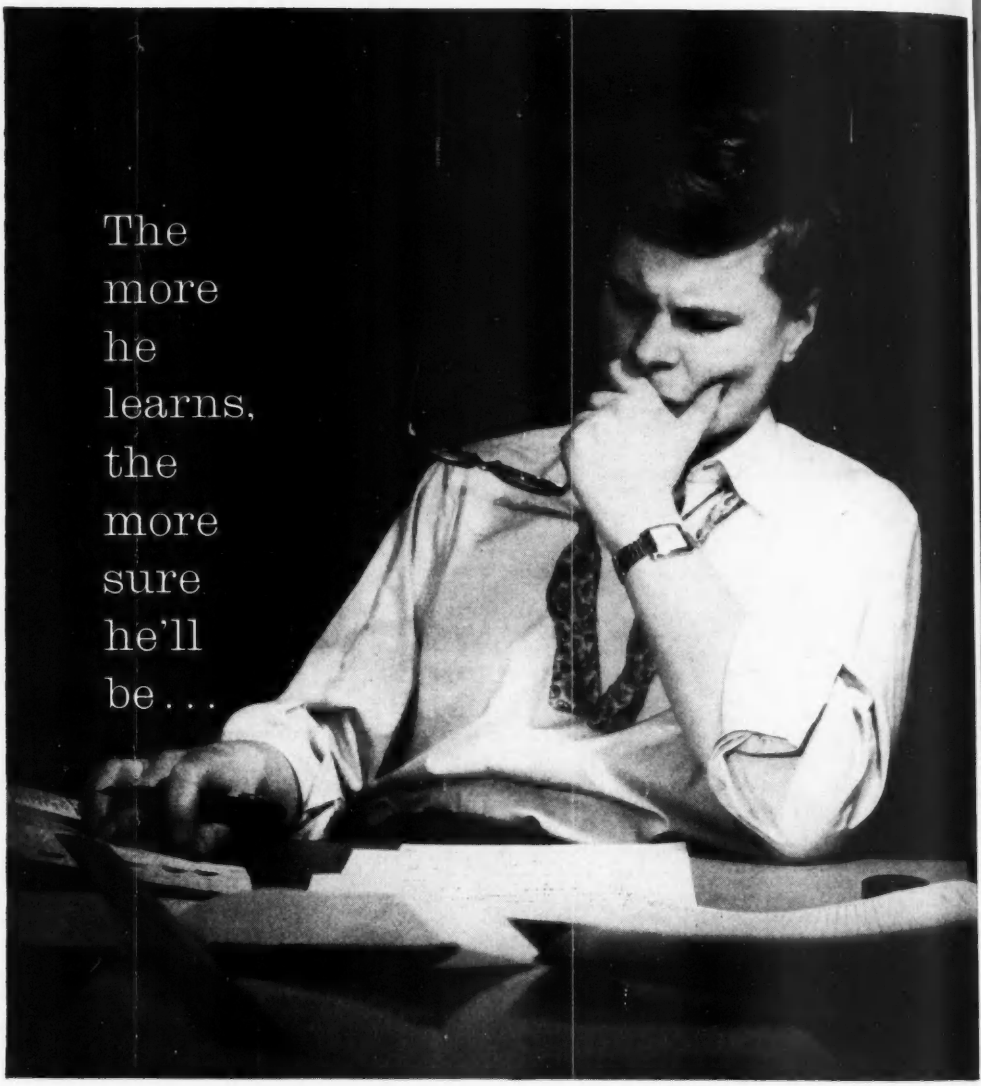

Where the problem involves the correct type of drive for new items of equipment, Morse Chain Engineers are always ready to call and advise you. When chain replacements are needed these can be obtained from stock depots conveniently situated in the important industrial centres.

the answer is always

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chain drives

MORSE CHAIN DIVISION, BORG-WARNER LTD., LETCHWORTH, HERTS. TELEPHONE 2170

Manufacturers of Automotive Transmissions, Torque Converters, One Way Clutches, Morse Chains and Hartcliffe Chains

B·W

During the **Swiss Industries Fair,** to be held at Basle from November 10 to 15, 1959, the **Association of Swiss Chemists,** in collaboration with the **Swiss Association of Automation,** will hold an international congress and exhibition of laboratory, measurement, and automation techniques in chemistry.

London & Thames Haven Oil Wharves Limited have appointed **Pencol Pipeline & Engineering Consultants,** of 19 Grosvenor Place, London, S.W.1, as consulting engineers and designers for their new multiple-product automated road-car loading station, which will have a capacity of 250,000 gph.

Ashmore, Benson, Pease & Company have concluded a licence agreement with the **Mond Nickel Company Limited** by which they can now supply spheroidal-graphite or high-ductile iron castings in accordance with B.S.2789:1956.

International Plastics Limited announce the signing of an agreement with **Baehre Metallwerk, K.G.,** of Springe, Hanover, for the exchange of technical information and the rights of sale of small-particle board plants, under the name of Bartrev-Bison, in the U.K. and overseas.

The Cape Asbestos Company Ltd. has acquired the whole of the share capital of **William Turner (Kismet) Ltd.,** of Eyre Works, Sheffield.

Metal Industries Limited, who recently made an offer for the 2,500,000 shares in **Avo Limited,** announce that they have received acceptances in respect of more than 90% of Avo's capital, and the offer has accordingly become unconditional.

Macfarlane Watson Ltd., of 36 Beauchamp Place, London, S.W.3, announce that they are organizing an exhibition and convention, entitled " Pneumatics and Hydraulics for Industry ", at Alexandra Palace, London, from October 12 to 16, 1959.

David Brown Industries Ltd. announce the signing of an agreement which gives the company exclusive manufacturing rights in Britain of a patent form of radiation shielding, perfected in the U.S.A. by **Knapp Mills Inc.,** of New York, and with particular application in the field of nuclear power.

The London office of **Rocol Ltd.,** of Swillington, near Leeds, has moved to General Buildings, Aldwych, London, W.C.2 (Tel: HOLborn 1985).

The Jerrican Division of J. E. Lesser & Sons Limited, of Green Lane, Hounslow, announce the formation of an associate company, **Recontainers Limited,** which will operate from the same address as the parent company.

CONTRACTS

Cooke and Ferguson Ltd., a member of the Crompton Parkinson Group of Companies, has been awarded a contract by Durban Corporation, South Africa, for a new substation at Mitchell Park.

Brookhirst Igranic Limited, the electrical subsidiary of the Metal Industries Group, has secured an order worth more than £150,000 for equipment for the Central Electricity Generating Board's Skelton Grange " B " power station at Leeds.

A $2,000,000 order for electronic equipment, which is claimed to provide Trans-Canada Air Lines with the fastest and most modern seat-reservation system in the world, has been announced by Ferranti-Packard Electric Limited, the wholly-owned Canadian subsidiary of Ferranti Ltd.

Contracts worth nearly £4,500,000 have been awarded to the Mitchell Construction Co. Ltd., by the North of Scotland Hydro-Electric Board for their Strathfarrar/Kilmorack Hydro-Electric Scheme near Beauly, Inverness. The work involves the construction of the Deanie tunnel, the Monar dam, and the Culligran tunnel and power station.

One of the largest single contracts for a microwave network in Europe, worth approximately £750,000, has been placed with Standard Telephones and Cables Limited by the Royal Board of Swedish Telecommunications. It provides for a propagation survey of the proposed routes to determine suitable sites for the equipment stations, and for the supply and installation of microwave equipment for operation in the 4000-Mcs band.

Wild-Barfield Electric Furnaces Ltd., of Watford, have received an order from The Standard Motor Co. Ltd., for a special pit-type furnace for use in their metallurgical research laboratory.

The first of two orders for a total of 2152 miles of submarine cable at a cost of £3,000,000 has been awarded by Cable and Wireless Ltd. to Submarine Cables Ltd., of London. The cable will be made at the Telcon Works, Greenwich, and will be laid across the Atlantic between Scotland and Newfoundland in 1961. It will be the first ocean link in the 30,000-mile Commonwealth round-the-world telephone cable, estimated to cost £88,000,000.

ELECTRICAL ENGINEERS' EXHIBITION

The Electrical Engineers (A.S.E.E.) Exhibition was opened at Earls Court on March 17 by Lord Brabazon of Tara, who emphasized that the electrical industryw as the second largest exporter in the U.K. and that there was every reason to expect a further expansion in the export of electrical products. The first prize of the exhibition was awarded to the Brush Electrical Engineering Company Limited for their dry flameproof transformer for mines, while in the domestic section Dimplex Limited topped the list with their portable infra-red fire. To celebrate the golden jubilee of the Illuminating Engineering Society, special stress was laid on the display of modern illuminating techniques. Altogether, the exhibition attracted more than 68,000 visitors, 639 of whom came from 71 foreign countries.

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METAL FATIGUE

Edited by

J. A. POPE

395 pages *Illustrated* *70s. net.*

This work derives from a course of lectures held at Nottingham University. Each chapter represents one lecture, and the whole divides naturally into three parts : The Fundamentals of Fatigue : The Fatigue Properties of Engineering Materials and Components ; and Fatigue Testing of Engineering Components.

PATENTS FOR ENGINEERS

by

L. H. A. CARR, & J. C. WOOD, LL.M.

107 pages *18s. net.*

This book meets the need for a work which not only deals with patent law in simple form, but especially with its engineering and commercial aspects.

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Ten licensees are now manufacturing Hydrovane Compressors throughout the world.

To the inherent features of Rotary Compression are added the further advantages of
- **Cool oil-free air.**
- **Fewer working parts than any other type of compressor.**
- **Negligible wear and tear under oil flood.**
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Compact design and above all LOWER INITIAL COST.

POWER TRANSMISSION EQUIPMENT

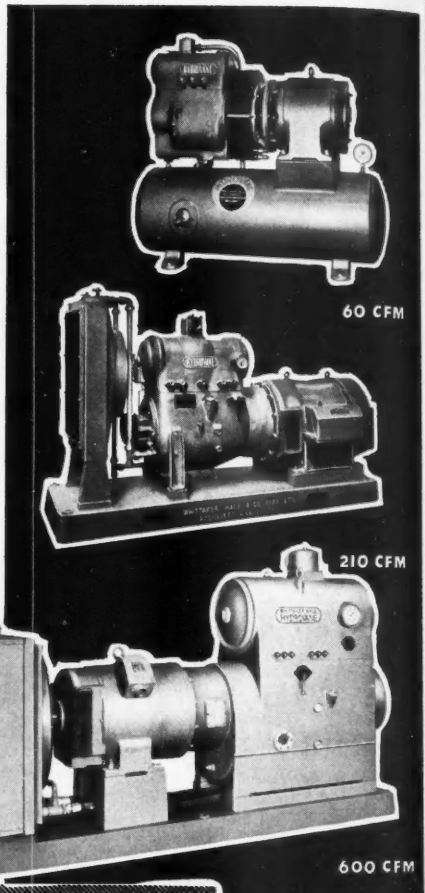
HIGH SPEED MULTIPLE DISC CLUTCHES ❶
Powerful, clean in contour and ideally suitable for machine tool drives, etc., these clutches do not need frequent adjustment.

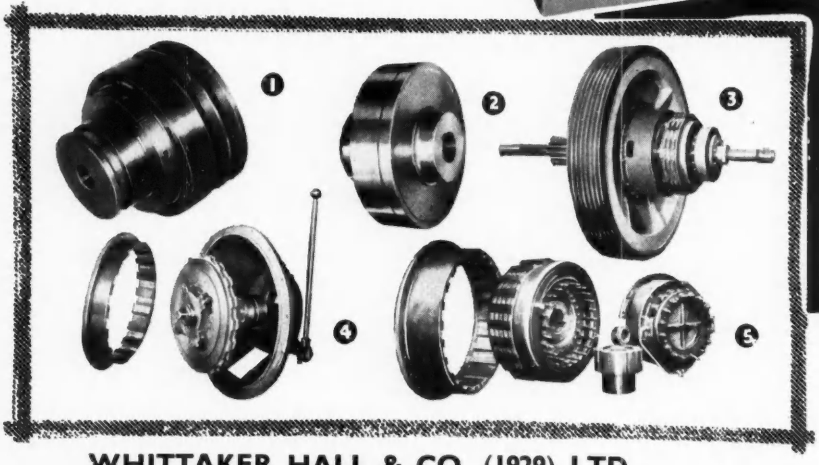
FLEXIBLE COUPLINGS ❷
A new design of great efficiency that is suitable for either direction of rotation.

PNEUMATIC CLUTCH-BRAKE ASSEMBLIES ❸
Suitable for presses, shearing machines, forging machines, and other heavy duty drives.

POWER TAKE-OFF CLUTCH ASSEMBLIES ❹
A range of self-contained units for Diesel and Petrol engines to drive all kinds of machinery.

CLUTCH-BRAKE ASSEMBLIES ❺
The illustration shows a pneumatic Clutch-Brake Assembly supplied for a 500 ton capacity forging machine.





All free air capacities 100 PSI running at 1450 RPM and direct coupled to flange mounted squirrel cage motors.

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CONFERENCE ON QUALITY IN INDUSTRY

Organized jointly by The Institution of Production Engineers, The Institution of Engineering Inspection, and The British Productivity Council, a conference will be held on " Quality in Industry " at the Palace Hotel, Buxton, on June 18 and 19, 1959. Details of the conference can be obtained from the conference secretary, The Institution of Production Engineers, 10 Chesterfield Street, London, W.1.

CONTINUOUS RENTAL PROGRAMME FOR MACHINE TOOLS

To provide new machine tools without capital expenditure, a continuous equipment-rental programme is announced by B. Elliott (Machinery) Ltd., of Willesden, London, N.W.10. About 100 different machine tools are offered, permitting the equipment of a complete machine shop on a rental basis, provided that the total value of machines exceeds £350. After a three-year minimum rental period, the machines can be returned, rented for further periods at a reduced rental, or exchanged for new machines on favourable rental terms.

NEW HOT-ROLLING MILL FOR STAINLESS STEEL

Work has started on a £1,000,000 scheme to modernize and expand the stainless- and alloy-steel sheet rolling plant at Samuel Fox and Company, Limited, of Stockbridge, a subsidiary of The United Steel Companies Limited. The development is being carried out in two stages, i.e, the existing cold-rolling mill will first be widened to produce sheets up to 72 in. wide, and will then be followed by the installation of an entirely new hot-rolling mill for sheets and light plates up to 72 in. wide, which will come into operation by 1960.

NEW PLANT FOR THE MANUFACTURE OF GERMANIUM RECTIFIERS

After over 50 years manufacture of high-power mercury-arc rectifier equipment, the Hackbridge and Hewittic Electric Company, of Walton-on-Thames, has now enlarged its facilities to include the supply of rectifiers employing semiconductor elements for low- and medium-voltage applications, and has in full production an extensive department for the complete manufacture, assembly, and testing of germanium diodes of the air-cooled and water-cooled types for use in Hewittic rectifiers. The company early recognized the possibilities of this new type of rectifier and, as a result, has been proceeding with research and development for several years. The plant now installed has been scientifically arranged in a new extension in which every facility has been incorporated for the most effective production.

" DROP FORGERS IN STEEL "

Some idea of the intrinsic merit of the new film " Drop Forgers in Steel ", presented by The English Steel Forge and Engineering Corporation, may be gained from the fact that it has been selected for viewing at the Festival of Films in the Service of Industry, to be held at Harrogate from April 21 to 24, 1959. Commencing with a general description of the Sheffield drop-forging plant of the company, this interesting and extremely well-produced colour film covers the entire sequence of drop-forging operations, from the melting of the steel and teeming of ingots to the final forging and heat treatment of the finished products, such as gear blanks, crankshafts, and other components used in various industries. In addition, details are included of the various metallurgical and mechanical tests and of the careful inspection carried out on every workpiece before it leaves the plant.

It is an additional merit of this excellent film, which has been produced entirely by the film unit of The English Steel Corporation, that it contrives to be entertaining as well as instructive, disseminating its technical information and arousing interest in drop-forging without becoming tedious or swamped by inconsequential details.

Classified Advertisements

UNIVERSITY OF BIRMINGHAM
WILMOT BREEDEN RESEARCH FELLOWSHIP, 1959

Applications are invited for a Research Fellowship to be held in association with the University of Birmingham. The value of the Fellowship, which is for a two year term is £1,000 p.a.
A candidate for the Fellowship should normally have had two or three year's research or industrial experience. He must be acceptable to the University and would be expected to have an Honours degree of a University in the British Commonwealth, a Diploma in Technology or an equivalent qualification.
The Wilmot Breeden Fellow will engage in an enterprise of such a character as to require the facilities both of the University and the Company, and his time will be divided between the two. The activities with which the Company is especially concerned include Mechanisms, Electro-Chemistry, Metal Finishing, Metallurgy, Metal Formation, Hydraulics, Electronics.
Full details may be obtained on application to the Secretary, Wilmot Breeden Limited, Amington Road, Birmingham, 25. Final applications must be received by the Secretary before 1st May, 1959.

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DRIVES LIKE A NAIL
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An entirely new introduction, Monel 'Anchorfast' nails have most of the advantages of screws for fixing, but can be used as easily as nails. They are so designed that when driven into wood, the grooves in the nail shape the wood fibres into scores of tiny wedges which grip the fastening so tightly that vibration cannot shake it loose.
Write for literature and samples

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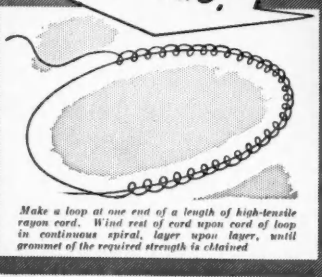
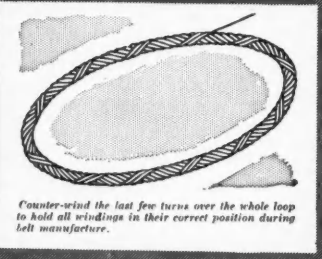
Symmetrical construction gives balanced drive—which is maximum drive. No central cords to "dish" the belt, no turning over in the pulley groove. And what flexibility, what driving grip . . . with all that rubber!

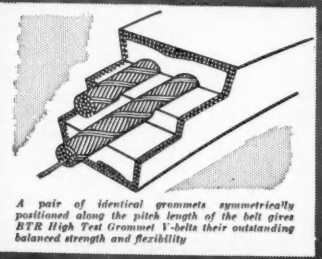
How a BTR GROMMET is made!



Make a loop at one end of a length of high-tensile rayon cord. Wind rest of cord upon cord of loop in continuous spiral, layer upon layer, until grommet of the required strength is obtained



Counter-wind the last few turns over the whole loop to hold all windings in their correct position during belt manufacture.



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A.C. Circuit Analysis. Edited by Alexander Schure, Ph.D., Ed.D. 104 pp., 49 illustrations. Publishers: John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, N.Y. Price: $1.80.

Although the mathematical treatment in this book, which may be considered complementary to "D.C. Circuit Analysis", another in the Electronic Technology Series published by Rider, is essentially simple, the analyses are sufficiently extensive to permit full comprehension of the pertinent theory. For this purpose, the text presents information relating to electrical laws in such a way as to permit their ready use, describing a relatively small number of major topics in detail, and including a number of selected problems to illustrate the principles and equations involved.

The Technical Writer. By J. W. Godfrey, F.R.S.A., and G. Parr, M.I.E.E. 340 pp., 110 illustrations. Publishers: Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 45/–.

This outstanding book, undoubtedly one of the best and most comprehensive of its kind ever published, is an indispensable aid to all those technical writers who wish to express themselves concisely and clearly. With the present tremendous output of technical literature, it is not surprising that there are many experts in a given field who are, unfortunately, unable to put over their ideas in writing—or, at least, in *good* writing. This book is therefore of inestimable value in helping to eradicate the all-too-frequent presence in technical literature of poor grammar, careless punctuation, and irritating ambiguities in phraseology.

Quite apart from laying down the principles on which good writing is based (and how lucidly and entertainingly the authors manage to lay down these principles!) the book affords an insight into the technique of presentation and production. Indeed, a considerable portion is devoted to such subjects as printing processes, methods of reproducing illustrations, typography, setting out text and mathematics, and editorial procedure. It may, perhaps, be argued that the inclusion of a wealth of such data is unnecessary, as it is hardly likely to be of much use to writers. On the contrary, we feel that this information is not only valuable to writers, but also helps to relieve the lot of editors, on whom, after all, falls the onus of having to prepare and correct the manuscript for publication. By helping to familiarize writers with the processes through which manuscripts pass after they leave author's hands, it is possible to ensure that the finished product will be as efficiently and neatly presented as is economically feasible.

In short, this excellent publication is not only a valuable guide to inexperienced technical writers, but is also a useful reference book and "refresher" for expert writers and (tell it not in Gath!) for editors themselves.

British Plastics Year Book, 1959. 29th edition. 644 pages. Publishers: Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price: 42/–.

As usual, this invaluable guide is of inestimable service to all those connected with the plastics industry and to manufacturers and users of machinery and equipment. This 29th edition has been thoroughly revised and has now been divided into ten sections, including comprehensive lists in classified form of raw materials, manufactured products, plant and equipment, technical and general data applicable to the plastics industry, a "who's who" of prominent people in the industry, and the names and addresses in the U.K. and overseas of firms, organizations, consultants, periodicals, etc.

As before, all sections are conveniently tabbed and a detailed index is included, together with a glossary of technical terms and tables of the properties of plastics.

Spring Design and Calculations. 9th edition, 1958. By John A. Roberts, M.Inst.B.E. 136 pp., 34 illustrations. Published by the Technical Research Laboratory, Herbert Terry and Sons Limited, Redditch. Price: 10/6.

Although considerable research is being carried out on spring materials, optimum spring performance is unlikely to result unless the spring concerned is correctly designed for the particular purpose it has to fulfil. This little book, compiled by one of the leading authorities on spring design in Great Britain, will therefore prove of great interest and practical value to all concerned with springs, either as users or buyers.

Despite its compactness, the book is none the less comprehensive. Virtually every type of spring is covered, including helical compression and extension springs and their calculation, square- and rectangular-section springs, volute springs, conical springs, valve springs, clock-type springs, flat springs, and multiple leaf or laminated springs. In addition, details are given of such items as Belleville washers, waved washers, circlips or retaining rings, and spring driving belts. Chapters are also included on frequency, the velocity of helical springs, springs with material subject to bending stresses, and combined axial and horizontal loading on compression springs, together with a number of useful tables of spring data and spring materials.

Conductance Design of Active Circuits. By Keats A. Pullen, Jr., Eng.D. 344 pp., 172 illustrations. Publishers: John F. Rider Publisher, Inc., 116 West 14th Street, New York 11, N.Y. Price: $9.95.

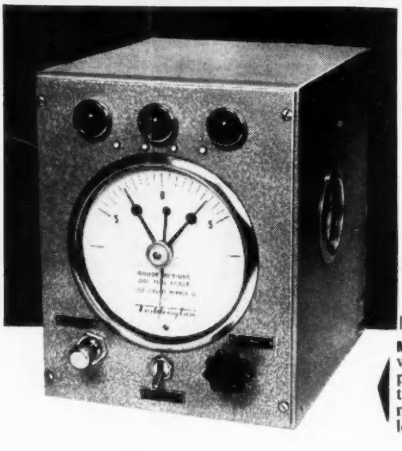
Although the techniques described in this book have been developed and used successfully for some years, this is believed to be the first textbook published on the use of conductance curves in the design of valve and transistor circuits. These techniques can reduce design and development time, reducing circuitry to a simple science which can be applied to good advantage in the design of commercial, industrial, and military electronic equipment.

This well-written and produced book discusses the design of circuits for use with active devices in terms of a combination of their small-signal and static or d.c. behaviour, showing the relations of the circuit to the device and indicating the method of ensuring steady and reliable operation of the combination. The conductance approach utilizes a technique in which a non-linear circuit may be linearized on a point-by-point basis, and the theory and mathematics involved are clearly explained and illustrated. In addition, the conductance theory, as applied to the design of a wide variety of vacuum-tube and transistor-amplifier, mixer, and oscillator circuitry, is presented, together with numerical examples to make it more thoroughly understandable.

Metal Fatigue. Edited by J. A. Pope, Ph.D., D.Sc., Wh.Sch., M.I.Mech.E. 395 pp., 282 illustrations. Publishers: Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 70/–.

Presenting a clear picture of the present state of knowledge of the fatigue of metals, insofar as it affects engineering designers, this useful book is a collective work, derived from a week's residential course on the fatigue of metals held at the Engineering Department of Nottingham University, and covering twenty lectures by various experts in a particular branch of the subject. Some of the lectures were given by members from the University, and the others by members from industry, research associations, and Government departments.

In this book, the substance of the lectures remains unaltered. Each chapter represents a lecture, the whole being divided into three parts, i.e., (1) the fundamentals of fatigue (8 lectures), (2) the fatigue properties of engineering materials and components (8 lectures), and (3) fatigue testing of engineering components (4 lectures). A useful synopsis of each chapter is given, and a large number of illustrations and pertinent tables is included.



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